# REPORT OF THE TWENTY-SIXTH ALFALFA IMPROVEMENT CONFERENCE

South Dakota State University
Brookings, South Dakota
June 6-8, 1978

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Reported by
D. K. Barnes, Permanent Secretary

Twenty-seventh Alfalfa Improvement Conference to be held
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University of Wisconsin
Madison, Wisconsin

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TWENTY-SIXTH ALFALFA IMPROVEMENT CONFERENCE

Program Chairman--M. D. Rumbaugh

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# Introduction

The 26th National Alfalfa Improvement Conference (NAIC) met concurrently with the 19th Forage Insect Research Conference and the 4th NC Regional Forage Specialist Workshop at South Dakota State University, Brookings. One joint half-day session was held, devoted to "Insect damage to alfalfa in range and pastures" and to "Aphids an international problem". There was also joint participation in field trips highlighting forage research at South Dakota State University.

The conference was opened by M. D. Rumbaugh, chairman of the NAIC. Dr. R. A. Moore, director of the South Dakota Agricultural Experiment Station, welcomed the participants and briefly described the importance of Agriculture, especially alfalfa, to South Dakota. A special address, "The future of alfalfa for pasture in dry regions and research requirements" was presented by Dr. D. H. Heinrichs. This address was very appropriate for the conference because many of the germplasms used in the development of pasture types alfalfas were first introduced into South Dakota by Dr. N. E. Hanson early in this century. Dr. Heinrichs, 23rd NAIC chairman, was the primary alfalfa breeder developing pasture type alfalfas for North America until his recent retirement.

To further emphasize the importance of pasture-type alfalfas, an overnight post-conference bus tour was conducted to the 2,700 acre Pasture Research Center in Norbeck, S. D. Research observed included a series of grazing experiments, pasture and forage systems, and interseedings of pasture alfalfas into native range. The use of large areas (50 acre pastures) to realistically investigate the effects of pasture variables on beef steer and cow-calf performance was impressive.

This report contains the two special addresses, abstracts of research studies reported, committee reports, business transacted, and information on distribution of conference reports and membership. From the entomological standpoint, this report covers only the session held jointly with the entomologists. A complete report of the Forage Insect Conference is being prepared by Dr. C. R. Ellis, Department of Environmental Biology, University of Guelph, Guelph, Ontario, Canada, N1G 2W1.

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Members of the executive committee of the 26th NAIC follows: M. D. Rumbaugh, chairman, Logan, Utah; E. T. Bingham, Madison, Wis.; A. M. Decker, College Park, Md.; R. L. Ditterline, Bozeman, Mont.; J. L. Mings, Washington, Iowa; G. R. Manglitz, Lincoln, Neb.; L. A. Derscheid and C. R. Krueger, Brookings, S.D., and D. K. Barnes, permanent secretary, St. Paul, Minn. Copies of this report are available from D. K. Barnes, USDA-SEA-AR, Department of Agronomy, University of Minnesota, St. Paul 55108.

## Welcome to South Dakota

R. A. Moore, Director
South Dakota Agricultural Experiment Station

We want you to feel welcome. I'm pleased to have this opportunity to welcome you to our campus. Of course, we like to welcome all visitors but we wanted our welcome to this group to be very special. I do not consider this a ceremonial responsibility or obligation on my part. Instead, I deem this a distinct honor. I first became associated with the alfalfa research work at this university more than 20 years ago.

Alfalfa and all forages are important to South Dakota. Some very interesting and exciting events have occurred in alfalfa in this state during this century. Many of you are familiar with that story. It's the story of Dr. N. E. Hanson and his worldwide search for plant materials.

Dr. Hanson is the man who brought crested wheatgrass, smooth bromegrass and a variety of fruit and shrub materials to America. But, he also introduced a wild alfalfa which he collected from the dry and barren vastness of Siberia. His notes reveal his humor and the realities of our area. He wrote that this wild alfalfa was collected in an area that recorded 10 inches precipitation and temperatures ranging from minus 50 degrees fahrenheit to 110 degrees fahrenheit. He said, this material "should have a chance in South Dakota."

Although he would not admit to being either a prophet or the son of a prophet his notes were indeed prophetic. "This material might be successfully introduced as wild plants into the native ranges of the prairie northwest." At another time he said, "to increase the carrying capacity of our present rangeland, now unfit for cultivation, by bringing in as a wild plant the yellow-flowered Siberian alfalfa is certainly a work worthwhile."

Recently I traveled with the commissioner of higher education of South Dakota and the president of this university to view several of our field stations. I wish each of you could have been along. You would have noticed how agricultural we are. You would also have noticed the diversity of our agriculture from corn and soybeans in the southeast to the vast sheep and cattle ranges of the northwest. In between, we raise a lot of sorghum, barley, hay, sunflowers, and many other crops.

We rank second in the production of oats, rye, and flaxseed, fifth in sheep production, and ninth in cattle. Three-fourths of the agricultural income generated in South Dakota comes from livestock, but in saying this, I want to acknowledge immediately that nearly 30 million acres of rangeland, pastures, and forages along with 10 million acres of feed grains support our livestock economy. I am told that we have some of the finest mixed prairies on the North American continent.

Alfalfa and all forages are important to South Dakota, and you who work to improve this crop are important to all of us. We welcome you to this land of infinite variety and well it is. Our climate, our soil, and even our people are all infinitely variable.

We welcome you to our campus, a university of 7 colleges and 6,500 students with emphasis on quality, service -- and education with a purpose. We hope you have an opportunity to look the campus over. We have many new buildings with exceptionally fine facilities.

Yes indeed, you are most welcome to our state -- the land of Crazyhorse and Redcloud, the home state of Hubert Humphrey and Dr. Ernest Orlando Lawrence, the man who first cracked the atom. This is the home of Edgar S. McFadden who put rust resistance into wheat. It is said of him, "he provided a bountiful harvest for his fellow farmer and to a hungry world he gave bread." We have the world's only Corn Palace plus the Shrine of Democracy, which 2 years ago was the focal point for our nation's bicentennial.

This is a hunting and fishing paradise. Perhaps you will have an opportunity to cast your bait in one of our great lakes on the Missouri or in the Northeast area of the state. Or, you might try a fly in a mountain trout stream in the Black Hills.

This is the land where in a single day snow may fall in the Black Hills. hail in the badlands, a tornado touch down just west of Pierre, rain in the east, but sun shine on the praries.

Indeed it is, the land of infinite variety. We are glad you are here. The agenda for the conference looks extremely good. I trust it will be productive and enjoyable. I look forward to joining you in many of the sessions.

## The Future of Alfalfa for Pasture in Dry Regions and Research Requirements

D. H. Heinrichs
Agriculture Canada, Retired
Victoria, British Columbia

I am indeed pleased to have been invited to speak at this Conference on the role of alfalfa in future pasture production on dryland. In my view, alfalfa has not received the attention it deserves to make it more useful as a pasture and rangeland plant. Now and then attempts have been made by far-sighted scientists, farmers and ranchers to exploit its productive capacity in a pasture program, but always there has been a regression because the research effort was not sustained to overcome the lack of persistence of alfalfa cultivars and the bloat hazard.

No perennial legume has yet been found that can match alfalfa in efficiency of nitrogen fixation in regions where annual precipitation fluctuates between 250 and 500 mm. Therefore, this legume must be introduced into our vast grassland region of North America to maximize production and to maintain soil fertility. Alfalfa and grasses, growing together, can become a solid base for ecological and productive stability of our vast semiarid regions, destined by climatic conditions to be used as pasture by ruminants.

The value of alfalfa in dryland pastures has been demonstrated over and over again in Saskatchewan, Alberta, Manitoba, Montana, and North and South Dakota, and yet it is my guess that over 70 percent of pastures and rangelands in these areas are producing at only 30 percent of potential because there is no alfalfa or other legume in these grazing lands.

The great advantage of alfalfa in a mixture is forcibly illustrated by data from an experiment seeded in 1946 at Swift Current. The grass mixture, consisting of crested wheatgrass, intermediate wheatgrass and Russian wild ryegrass yielded 780 pounds per acre over a period of seven years while the same mixture with Ladak alfalfa yielded 2070 pounds per acre, or three times as much pasturage. In 1952, the sixth crop year, when moisture conditions were above average, the grass mixture yielded only 250 pounds per acre while the grass-alfalfa mixture produced 4500 pounds per acre, or about 16 times as much pasturage. The following year the grass recovered somewhat and produced 1120 pounds per acre compared to 2840 pounds for the grass-alfalfa mixture. It is obvious from these results that the lack of available nitrogen in the soil contributed more to low production of the grass than the drought.

In a pasture experiment conducted with sheep on hilly land in the early 1950's, the lamb and wool income over a five-year period from the grass-alfalfa mixture was $16.20 per acre while that of grass alone was $2.80. This clearly indicates the importance of alfalfa in making a grazing proposition profitable or not.

In a recent cow-calf pasture experiment on Drylander alfalfa and Russian wild ryegrass seeded in mixture, in cross-seeded rows and in alternate rows, calves gained an average of 2.5 pounds per day over a 2½-month summer grazing period. In addition, cows gained about a pound a day during the period. There was little difference in calf growth on the different "patterns of seeding" pastures. However, after four years of grazing, the basal ground cover of the alfalfa component was twice as great in the cross-seeded and the alternate-row seeded pastures as in the mixed seeded pasture while the basal ground cover of the grass remained constant. Regardless of seeding pattern, no bloat occurred on the pastures during four years.

A serious breeding project with the object of developing more persistent alfalfa cultivars for the dry Prairie Region of Canada was initiated at the Federal Government Research Station at Swift Current, Saskatchewan in 1938, immediately after the "Great Drought", by two well-known forage crop scientists, Dr. S. E. Clarke and Dr. J. L. Bolton. The latter is well-known to many agrologists attending this conference. The breeding objective was stated as: "To develop more persistent and winter-hardy alfalfa cultivars for the dry Prairie Region of Canada". During the early phases of the breeding program the aim was to combine the winterhardiness and persistence qualities of Siberian Medicago falcata with the good seed producing qualities and growth vigor of the cultivar Ladak.

The Siberian alfalfa that was used in the breeding program originated from seed samples distributed by Dr. N. E. Hanson, South Dakota State College, Brookings, from collections he made in Siberia during two exploration trips between the years 1897 and 1909. Seed was distributed by Dr. Hanson not only to research institutions across the United States and Canada but also to farmers. I was familiar with two farmers' fields near Swift Current where Siberian alfalfa had persisted in stands from 1916 to 1956 or 40 years. It was no wonder, therefore, that this source of Siberian yellow-flowered alfalfa was chosen for the breeding program at Swift Current. We used several strains of Siberian, one of which originated from Dr. Hanson's selections near Yakutsh in Siberia where the temperature dips to -65°F in winter. In 1906, this man of vision stated: "My estimate still holds that this Siberian alfalfa will extend the alfalfa belt on this continent to the Arctic Circle whenever that becomes necessary."

I don't know whether or not it is a coincidence that I speak on alfalfa here at Brookings, the home of Siberian alfalfa breeding material that was so generously provided by the State University at Brookings and used by us in Swift Current. It certainly was instrumental in the development of the first truly creeping-rooted alfalfa cultivar on this continent and perhaps the first in the world. Its name is "Rambler."

I became actively associated with the alfalfa breeding program at Swift Current, Saskatchewan, in 1947 and took it over in 1949, after completing studies toward a Ph.D. degree under the eminent plant breeder, Dr. H. K. Hayes at the University of Minnesota. I actually was his last graduate student and consider myself most fortunate to have had the opportunity to study under his guidance and direction.

In 1947, large populations of first, second, and third generation hybrids were growing in breeding nurseries at Swift Current. They had accumulated

during the war years and provided a wealth of material for selection. The creeping-root character was evident in numerous lines, and it seemed to me that it was a character most desirable in sustaining persistence in dry regions, especially in pastures. From then on the main selection criteria became strong creeping-root development, satisfactory seed set and reasonably good agronomic performance.

Breeding methodology followed the combining ability principles. The evaluation program involved grazing over techniques and harsh defoliation practices in the fall. Rambler emerged as the best strain among 24 synthetics and was licensed in 1955. Today, Rambler is used on about half the acreage sown to alfalfa-grass mixtures grown for hay and pasture on dryland in Saskatchewan and Alberta. Although bloat occurs in Rambler alfalfa pastures, this should not deter its use in pasture mixtures as cattle losses have been small. Whether or not creeping-rooted alfalfas cause less bloat than non-creeping-rooted types has not been proven but observations lean in that direction. However, it is not the creeping roots in themselves that have anything to do with it but rather the dispersed growth habit and the slower regrowth characteristic of these cultivars compared to the tap-rooted hay types.

In my view, and this has been corroborated by statements of others, *Medicago falcata* as a species has less tendency to cause bloat than *Medicago sativa* not only because it regrows more slowly but also because it is slightly more fibrous and perhaps somewhat less palatable.

After Rambler, three more creeping-rooted cultivars were developed at Swift Current and subsequently licensed, namely Roamer (1966), Drylander (1971) and Rangelander (1977). These cultivars express the creeping-root character to the following degree: in percent plants creeping-rooted -- Rambler 65, Roamer 65, Drylander 70, and Rangelander 80. Roamer and Drylander are quite resistant to bacterial wilt. Drylander is yellow-flowered, a very distinctive characteristic for this pasture alfalfa. Rangelander exhibits the ultimate in creeping-rootedness, first a high percentage of plants are creeping-rooted, and second, the plants have a high propensity to creep. Many plants have spread 20 feet across in six years. They readily spread into a stand of crested wheatgrass. I believe that for rangelands creeping-rooted alfalfas should be seeded at light rates, about one-half pound per acre. It seems that if the plant has room it will spread through a grass stand and shows a greater tendency for persistence.

No progeny line has yet been found at Swift Current in which 100 percent of the plants were creeping-rooted. The closest we have come to it is 95 percent. This is not surprising because the character is quantitatively inherited with many genes playing a role, and we have never gone beyond three cycles of selection. Achieving 100 percent creep development is not important from the practical point of view, although from the gene pool point of view it would be desirable to have pure breeding strains for the character.

I will digress at this stage and draw your attention to the fact that a wealth of creeping-rooted breeding material is stored under cool conditions at Swift Current, and breeding material is also stored in the gene pool banks in Ottawa and Colorado.

Creeping rootstalks are usually located 4 to 8 inches below the ground surface. They send up shoots at intervals, each of which is capable of becoming an independent plant. Some plants are dense creepers, others sparse; that is, certain plants produce more shoots per unit area than others. The sparse type of creeper may be better for dryland pastures than the dense type because in a mixed stand the alfalfa and grass plants tend to form a uniform, interspersed association. Also, there will be less tendency for the stand to become too dense during favorable moisture years resulting in a lower productive capacity during dry years.

In my opinion, a great wealth of research opportunities lies in the area of sorting out the specific agronomic value of various types of creepers.

I am convinced, along with other Canadian forage agronomists and farmers and ranchers, that creeping-rooted alfalfas are more desirable for pasture than non-creepers. Short term production may favor non-creeping types but in the long run, the creeping types will excel from the economic point of view because they persist longer and reseeding expenses will be much lower. Under reasonably good management practices, well-balanced productive stands of grass-alfalfa pastures can be maintained for 15 years or more -- that we have already observed in Saskatchewan and Alberta.

It is a fact that the presently available creeping-rooted alfalfa cultivars originated in northern regions where winters are long and cold. It is natural therefore, that these alfalfas have long dormant periods and slow regrowth characteristics. These are not desirable features in milder southern climates and these cultivars can't be used directly there, but the characters can be transferred to more suitable physiological types by breeding and selection. In Australia, plant breeders have already made considerable progress in this regard.

To develop useful alfalfas for pasture will require long-term sustained efforts on the part of plant breeders and agronomists, and that will be difficult to achieve in the present society which wants instant computer results. Our goals cannot be achieved by short term plans, which usually have a stated objective such as "to improve the yielding ability of alfalfa by 10 percent in 5 years." If we wanted to coin a similar objective for a pasture of alfalfa, we would be wiser to state "to improve the persistence of alfalfa by 10 percent in 10 years." Actually, such statements are a play on words, and the achievement is usually impossible to prove.

The main reason why I think we have been modestly successful at Swift Current in developing better alfalfa cultivars for pasture use on dryland was due to not changing our basic objective over a long time or the personnel involved with the project. I stayed with it from 1947 to 1976, a period of 29 years, and have no regrets.

The improvement of alfalfa for pasture is much more complex than its improvement for hay or protein production because we are dealing not only with the plant, but also with the effect of the grazing animal on it. In addition, pasture alfalfa for dryland must be very long-lived and tolerant to widely fluctuating changes in the environment.

It is obvious that generation turn-over in breeding alfalfa for pasture is much slower than for other uses because evaluation techniques are more involved. The usual three- or four-year test results will give little information on long-term persistence, or sustained production under grazing pressure. It is not surprising therefore, that few plant breeders have tackled the job of breeding alfalfa for pasture use. Just look at the breeding record among private seed companies. They have been very successful in adding a great many superior fodder cultivars to the recommended list, but have you heard of any pasture cultivars developed by them? I haven't. Not only is it a slow technical problem, but also the seed turnover is small.

There is no doubt in my mind that the greatest potential for agricultural production in North America lies in beef cattle through use of improved perennial grasses and alfalfa in the less productive lands, especially in the arid and semiarid regions of the western half of the continent. In the Canadian Prairie Provinces alone we estimate that at least 20 million acres of rangelands can be cultivated and seeded to tame grasses and legumes to provide permanent pastures that will produce three to five times as much forage for cattle as the native vegetation. Add the potential in the United States to this and the scope for the future is great indeed.

To meet the challenge in the future, breeding alfalfa for pasture use must receive attention from private seed companies as well as from government institutions and universities. The breeding progress need not be as slow as in the past when mass selection under grazing pressure was the method being used. We now know enough about various characteristics useful in a pasture alfalfa that breeding can be based on selecting for certain characters such as creeping roots, slow recovery, small leaf size, leaf retention as the plant ages, and appropriate chemical constituents to minimize bloat. Recent research conducted at the Canada Agriculture Research Station at Saskatoon, Saskatchewan, indicates that "low bloat" alfalfas are now a distinct possibility. I believe in this connection the breeder will have to pay as much attention to the physical structure of the plant as to its chemical composition if a truly good pasture type for dryland is to be developed.

Exploratory efforts for pasture type alfalfas have largely been neglected in the past 40 years or so. For northern North America we might go back into the vast Steppes of Siberia and see what can be found. I'm sure Dr. Hanson must have overlooked some useful material. For the southern, dry areas of this continent, the wild alfalfas of Spain, Northern Africa, and Iran deserve reexamination.

During my research career I always hoped that someday I would go on an alfalfa search trip through Siberia, but the best I managed was to get to the International Grassland Congress in Moscow and a short, closely guided tour in the Ukraine. At the Congress I got quite a kick out of the reaction of several young Siberian scientists who came up to me and asked me to autograph the talk I gave at the Plenary Session entitled, "Breeding Grasses and Legumes for Pasture in Canada." Evidently, whatever I said about breeding forage crops for pasture impressed them. This was the only agricultural message that I was ever asked to autograph in my entire career.

Recognizing a possibility is one thing, but making it happen is another. I hope that in the immediate future Directors, Coordinators of Research and agricultural planners can be motivated to appreciate the importance of improving alfalfa, specifically for pasture use on dryland and make monies available for that specific purpose. Cooperation between scientists of many disciplines -- plant breeders, agronomists, ecologists and ruminant nutritionists, will play an important role in the research program. I'm sure farmers and ranchers will be quick to accept the appropriate alfalfa cultivar as a pasture component so the cattle business may be much more productive and stable on this continent.

In conclusion, I am listing five of my papers that expound on the possibilities of alfalfa for pasture. I hope that these, along with the references in them and along with today's talk, will spark the beginning of renewed research on pasture alfalfas.

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# The Damage Potential of Some Grasshoppers Associated With Alfalfa

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Grasshoppers have been a major pest in the western United States since the first settlers crossed the prairie. Grasshopper problems increased as more land was planted to crops. Succulent forages, such as alfalfa, provide green food for grasshoppers after rangeland grasses become dry in mid-summer. All of the major grasshopper pests of alfalfa feed on both grasses and forbs but prefer forbs. However, of the 600 or so grasshopper species found within the United States and Canada only a few are pests of alfalfa. The most important are *Melanoplus sanguinipes*, *M. differentialis*, *M. bivittatus*, *M. packardii*, and *M. femurrubrum*. Very little quantitative information is available on alfalfa losses caused by grasshoppers. However, Morrill (1918) reported that an average of 1.2 g of green alfalfa was destroyed in a 24-hour period by one adult *M. differentialis* in Arizona, and Langford (1930) found that in Colorado one adult *M. bivittatus* destroyed .527 g of green alfalfa in 12 hours. Alfalfa seed losses were reported by York and Prescott (1947) as follows: a yield of 83.2 lb/acre from fields where grasshoppers had been sprayed and 24.7 lb/acre from unsprayed fields. Rearing studies (Brett 1947, Pfadt 1949, Smith et al. 1952, Barnes 1955, 1963, Baily and Mukerji 1976) have shown that alfalfa alone is an unfavorable food plant for the major grasshopper pests of alfalfa. Barnes (1959) noted that grasshopper populations in Arizona were higher in weedy alfalfa fields than in weed-free fields. Weed control or the application of chemicals should provide adequate grasshopper control in problem areas.

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## Grasshopper-Resistant Alfalfa Selected in the Field

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The differential grasshopper, Melanoplus differentialis (Thomas), is one of the most important grasshopper species attacking cultivated crops, particularly alfalfa, in Kansas. Although resistance to this species has been reported in wheat, barley, and corn, this is the first report of resistance to grasshoppers in alfalfa.

Following a heavy grasshopper infestation in which more than 99% of the plants in the field were stripped of leaves; 100 plants which had retained most of their leaves were transplanted from the field, along with an equal number having severe defoliation. The selected plants were vegetatively increased and evaluated for grasshopper resistance in the greenhouse and for agronomic characteristics in the field.

Resistance to field collected adults and reared numphs of the differential grasshopper was verified in the field selections by plant injury ratings, loss of plant weight, and percent of stems cut in greenhouse tests. Loss of plant weight also indicated possible resistance to three other grasshopper species; Encoptolophus sordidus costalis (Scudder), Melanoplus femurrubrum (DeGeer), and Schistocerca lineata (Scudder), which were tested as field collected adults in the greenhouse.

In the absence of grasshoppers, plants selected for resistance produced significantly more forage than did susceptible plants. The increased yield of resistant plants was attributed to a larger number of stems per plant; however, resistant plants had finer and shorter stems than susceptible plants. Although resistance mechanisms were not studied, nonpreference appeared to be the primary type of resistance involved.

## Potential Insect Pest Invasion of Alfalfa Seedings on Wildlands in the Great Basin

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Five genera containing species harmful to alfalfa occur in the sagebrush type:

*Colias* (Lepidoptera: Pieridae)
*Empoasca* (Homoptera: Cicadellidae)
*Euxoa* (Lepidoptera: Noctuidae)
*Loxostege sticticalis* (Lepidoptera: Pyralidae)
*Otiorhynchus* (Coleoptera: Curculionidae)

Aphids are not likely to cause serious damage to alfalfa when seeded with a mixture of native grasses, forbs, and shrubs. Army cutworms and other cutworms would attack alfalfa as readily as most other range plants. Hemiptera and some Homoptera would likely shift from the native vegetation to the succuluence of alfalfa.

All Nevada ants are omnivorous -- even the harvesters and honey ants. Most Nevada species tend and protect honeydew secreting insects. When aphids become numerous, the tending ants frequently eat some of them. Harvester ant seed preference is unknown.

In the greenhouse, *Labops hesperius* has shown it can feed and deposit eggs on alfalfa. *Apterona crenulella* (Bruand), a snailcase bagworm introduced from Europe, may become a pest on alfalfa.

Alfalfa plants closely spaced reduce habitat for beneficial spiders and for other natural enemies of harmful insects. It is recommended that alfalfa seedings contain a mixture of native grasses, forbs, and shrubs. Also, research is needed to show how native insects adapt to alfalfas.

# *Acyrthosiphon kondoi* (BAA) and *A. pisum* (PA) in New Zealand : A Review of the Problem and Progress in Research

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New Zealand alfalfa producers faced their first serious insect pest when *Acyrthosiphon kondoi* (BAA) was recorded in November 1975. *A. pisum* (PA) was first reported in March 1977, and by May 1978 both had spread into the important alfalfa producing regions.

Information on the biology of these aphids in New Zealand is scarce. Peak populations of BAA and flight periods are October-mid January and late March-mid June, with some variation due to local climate (5). PA peaks later in spring and earlier in autumn (W.M. Kain pers.comm.).

Losses from aphid infestation have been severe (2,3,5). Heavy BAA infestations in spring, summer, and autumn decreased yields 40, 30, and 72 percent, respectively, and caused 15 percent plant mortality in autumn (2). Production losses of 60 percent have been recorded following PA infestation.

Control has been achieved initially with insecticides, but grazing with sheep effectively reduces aphid numbers (5). Biological control is being attempted through importation and distribution of predators (incl. *Harmonia dimidiata*), and parasites (incl. *Aphidius ervi*, *A. smithii*, *Ephedrus plagiator*) (4).

Resistance of U.S. BAA-resistant selections has been verified in greenhouse and field trials (1). Resistance to PA with some exceptions follows U.S. results (Dunbier, unpubl.). Available BAA-resistant lines are unsuitable for New Zealand. They are either non-dormant and severely affected by foliar diseases, or susceptibility to bacterial wilt. We aim to release in October 1979 a semidormant cultivar with BAA, PA, and bacterial wilt resistance. Other lines are being screened for resistance to *Therioaphis maculata* (SAA) in Australia, as it is probable that SAA will be blown over from Australia by prevailing westerly winds.

International co-operation in characterising alfalfa aphid populations is desirable in view of their mobility and ability to develop biotypes with different virulence.

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# *Acyrthosiphon kondoi* and *Therioaphis trifolii* in Australia: A Review of the Problem and Progress in Research

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## 1. Distribution, damage, control and breeding programmes

The three main temperate pasture legumes in Australia are alfalfa (5 mill ac, 0.25 mill ac irrigated), annual medics (52 mill ac), and subterranean clover (42 mill ac). They are mainly rain grown and grazed. All alfalfa and most medic varieties are susceptible to SAA and BAA with sub clovers susceptible to BAA. Aphid damage to alfalfa has been estimated at $50 million per annum. SAA was first recorded in Australia in autumn 1977 (March 29) in south-east Queensland and was recorded in N.S.W., Victoria and South Australia within five weeks. It had spread to most alfalfa growing areas in Qld, N.S.W. and Vic. by winter 1977 and reached Western Australia in January 1978. It has not reached Tasmania. SAA infestations caused severe damage in autumn and spring 1977 requiring weekly sprayings at their peak. Some young stands were killed. Aphid activity in winter was much greater in the north than in the south. Populations fell from drought and native predators in late spring and summer 1977 except for irrigated stands in the south. Plague numbers built up again in autumn 1978 and began to decline in late autumn.

BAA was first recorded in late autumn 1977 (May 17) in south-east Qld and in N.S.W. within days. It reached Vic. in late spring 1977, Tas. in summer 1978, and S.A. in mid autumn 1978. It has not yet reached W.A. BAA spread in the north more rapidly and widely than SAA, in autumn 1977 causing widespread damage including death of some young stands. Heavy infestations continued in the north from autumn until late spring when drought and hot weather rapidly reduced them. Large numbers were again building up in late autumn 1978 in all eastern States.

A native *Entomophthora* fungus helped to control some northern infestations of SAA and BAA. Australia is using integrated control with four measures: chemical, biological using native and introduced agents, breeding resistant varieties, and importing resistant U.S. alfalfa varieties. Insecticide research enabled spray rates to be reduced by up to 75 percent and chemicals least damaging to beneficials to be selected. All States are monitoring populations of aphids and beneficials. Necessary background entomological research has been divided amongst the States and CSIRO. The SAA parasite *Trioxys complanatus* was introduced and mass reared by CSIRO, and co-operatively released within each State, except for S.A., who reared and released their own. The BAA parasites *Aphidius ervi* and *Ephedrus plagiator* have been introduced and distributed by CSIRO and Qld.

The aims of the four main alfalfa breeding programmes at Yanco/Deniliquin (CSIRO/NSW), Adelaide (S.A.), Brisbane (CSIRO/QLD) and Canberra (CSIRO) are to breed adapted SAA and BAA resistant varieties. Australia requires semi-dormant and non-dormant types for both hay and grazing. Resistance to anthracnose and phytophthora is generally important. In specific areas resistance is also needed to bacterial wilt, leaf diseases, stem nematode, sitona weevil and waterlogging. Breeders are proceeding first by directly selecting for SAA and BAA resistance in current breeding lines with no success in Hunter River based lines but with up to 1 percent SAA resistance being found in others. Second, by

crossing SAA and BAA resistance into current breeding lines using mainly CUF 101. And third, by rebreeding current breeding lines incorporating resistant germplasm. Parallel breeding programmes are being conducted for annual medics and sub clover.

11. Field evaluation of aphid-resistant varieties

Twenty two U.S. and four Australian alfalfa varieties have been tested at five sites in Victoria since 1974. The aim of the program was to overcome the problem of bacterial wilt. Fortunately, many of the U.S. varieties had resistance to SAA and the trials have provided an excellent guide to the most appropriate resistant varieties to replace the highly susceptible Australian varieties. ies.

Many of the U.S. varieties proved to be superior to Hunter River in both yields and persistence, even in the absence of the SAA. Due to the effect of SAA at one site in Northern Victoria, the yield of Hunter River in the fourth year was less than half that of the resistant varieties. Bacterial wilt resistance in many of the U.S. varieties has also proved to be of great value. In three trials more than 50 percent of Hunter River plants was infected with wilt in May 1978 while resistant varieties had only c. 10 percent infection with no significant effect on yield. The results are of particular significance because Hunter River had reigned for 100 years as the best adapted variety for Australia and before the SAA arrived was the only variety sown in most parts of the country. It has a semi-erect growth habit and is similar to Caliverde 65 in autumn and winter dormancy.

The relative performance of the different varieties was similar at all sites in Victoria. Semi-dormant varieties WL311, DeKalb Brand 167, Resistador 11, and AS-49 had slightly higher yields and significantly greater persistance than non-dormant types over the four year period. Although lower yielding in the first year, their excellent persistance, high spring and summer yields and relatively low spreading crown development are expected to make them highly successful in South-eastern Australia for both grazing and hay production. The non-dormant varieties WL-451, WL-501R, DeKalb Brand 185 and AS-13 have also been very successful and are being recommended for hay production and also for strictly controlled rotational grazing when higher winter production is required. Highly winter-active varieties such as UC Cargo gave high yields in the first year but did not persist as well as more dormant varieties, particularly when grazed. Considerable interest is being shown in CUF 101 but, despite the advantage of resistance to BAA, it is only recommended as a short rotation hay variety.

Some U.S. varieties tested proved to be unsuitable for Australian conditions. Varieties with greater winter dormancy than Lahontan gave lower yields. Varieties such as Thor and Saranac persisted poorly due to susceptibility to phytophthora root rot and southern anthracnose respectively.

Hunter River is no longer recommended in Vic. or N.S.W. and has largely been withdrawn from the market. About 550 tons of seed of 15 U.S. varieties were imported into Australia between August 1977 and April 1978. Extension programs by State Departments and seed companies have resulted in the rapid acceptance of the new varieties. Nearly 2000 acres will be registered in Vic. and N.S.W. in 1978 for certified seed production of the U.S. varieties.

# Alfalfa Aphids in Argentina

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In 1969, an intense attack by pea aphids (*Acyrthosiphon pisum*) virtually devastated the alfalfa fields of Argentina. Resistant varieties and the parasites *Aphidius smithii* and *A. ervi* were introduced from the United States. Pea aphid (PA) populations with peaks in spring and fall steadily declined until the 1975/76 crop season, during which the population experienced a substantial increase. Several observations made in the "Pampeana Region" indicated widespread activity of *Aphidius* sp.; of predators *Eriopis* sp.; *Hippodamia* sp.; *Coccinella* sp. and the fungus *Entomophthora* sp., mainly in the humid zone (Harcourt, 1975). Hyperparasites *Lygocerus* sp.; *Pachineuron* sp. and *Asaphes* sp. were the main mortality factors for *Aphidius* sp. (Aragon, 1975).

The blue alfalfa aphid (*Acyrthosiphon kondoi*) appeared in Argentina in early 1976 (Luna, 1976). The spread of the blue alfalfa aphid (BAA) has been very rapid. Preliminary surveys (Nielson, 1977) indicated that this new pest occupied an area of 1280 kilometers long and 640 kilometers wide between the 28th and 40th parallels. BAA population peaked in early spring and late fall amounting up to 60 to 90% in mixed populations of aphids. The *Entomophthora* sp. has been the only effective biological control agent available up-to-date.

The Project breeding program, in one cycle of recurrent selection in a population resulting from crosses among parental clones of Varsat and Anguil INTA (cultivars released by argentinian agronomist after a long term selection program), developed the experimental Paine INTA, grazing type cultivar. It is 75% resistant to the PA and 6.4% to the BAA, as compared to 53.3 for CUF 101. Intense screening has yielded nearly 100 genotypes from Paine and 28 from Fortin Pergamino, the latter a local cultivar having slight resistance to the BAA.

Regarding variety performance, under heavy aphid infestation, yields ranked according to their level of resistance. For example, during the 1975 PA infestation at Villegas Station, a resistant variety outyielded a local susceptible significantly in the first cutting. Forage dry matter production, 4 year average reached, 11.1 tons per hectare in the humid zone of the "Pampeana Region" (more than 800 mm.); 9.6 in the subhumid (700-800 mm.) and 5.7 in the semiarid (500-700 mm.). Team and WL 508 were outstanding for yield; Washoe, Kanza, and Dawson for their persistence. Best local cultivars in absence or light infestation of aphids were Polihibrido Manfredi, Fortin Pergamino for the humid and subhumid zones, and Varsat, Anguil INTA in the semiarid.

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## Development of Multiple Pest Resistance in Three Alfalfa Populations

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Three synthetic alfalfa populations (N.S. 77, 78, and 79) were developed from diverse germplasm sources at Lincoln, Nebraska. They were screened for added resistance to the pea aphid (PA) [*Acyrthosiphon pisum* (Harris)] and the spotted alfalfa aphid (SAA) [*Therioaphis maculata* (Buckton)] at Lincoln, Nebraska, and to stem nematode (SN) [*Ditylenchus dipsaci* (Kühn) Filipjev] and anthracnose (AN) (*Colletotrichum trifolii* Bain) at Reno, Nevada. Added pest resistance was incorporated by phenotypic recurrent selection.

Two cycles of selection for SN resistance were followed by three cycles of selection for AN resistance, uninterrupted by field evaluation. In another phase of this project, one cycle of selection for combined resistance to PA, SAA, bacterial wilt (BW) [*Corynebacterium insidiosum* (McCull) H. L. Jens], and potato leafhopper yellowing (PL) [*Empoasca fabae* (Harris)] was made at Lincoln after the first cycle of selection for SN resistance.

Two cycles of selection for SN resistance were effective in producing N.S. 77 and 78 populations with levels of resistance higher than that of 'Washoe.' While the level of SN resistance in N.S. 79 increased with each cycle of selection, the final level was less than that of Washoe. The relatively small initial number of class 1 resistant plants (28) in N.S. 79 was believed to have influenced the final level of resistance. Two cycles of selection in N.S. 78 and three cycles in N.S. 77 and 79 for AN resistance were effective in producing populations comparable to 'Arc' in resistance. The N.S. 78 base population included 42 germplasm sources, five of which were resistant to AN. One cycle of selection for combined resistance to PA and SAA in the greenhouse, plus resistance to BW and PL in the field in one season, increased the level of resistance to both aphid species in three populations.

Two cycles of selection for SN resistance did not change the level of SAA resistance in three populations and did not change PA resistance in two of three populations. There was a slight increase in level of PA resistance in N.S. 77 after selection for SN resistance. One cycle of selection for AN resistance, after two cycles of selection for SN resistance, resulted in no change in PA or SAA resistance in N.S. 79, an increase in PA resistance but no change in SAA resistance in N.S. 77. There were no changes in PA resistance but SAA resistance decreased in both N.S. 78 and 79 after two cycles of selection for AN resistance. Other evaluations are in progress.

Resistance to PA and SAA were similar in the Syn-1 generation produced by hand crossing and by caged pollination among stem nematode resistant plants in three populations.

Selection for stem nematode and anthracnose resistance, and increased resistance to pea aphid and spotted alfalfa aphid has increased forage yield without changing persistence or growth habit, based on preliminary Nebraska field data.

# Alfalfa as a Grazing Plant: What We Know that Ain't So

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"The trouble ain't that we don't know but that we know so much that ain't so!" remarked Josh Billings. We "know" that alfalfa is a fine grazing plant; animal production on alfalfa or alfalfa-grass pastures has been as high as 1050 kg of beef or 950 kg of lamb/ha under irrigation, over 200 kg of beef/ha on range, and nearly 7000 kg of milk/ha (13). However, alfalfa stands deteriorate quickly under continuous grazing and rotation grazing is recommended for stand maintenance and continued high animal performance.

The fact is that alfalfa is a hay plant, adapted to infrequent but nearly complete herbage removal (2, 5, 9, 11, 12). Plants more adapted to grazing, such as birdsfoot trefoil, can tolerate frequent partial herbage removal (12). Alfalfa produces new shoots from crown buds in the spring, then from buds on stem bases later in the year (7,8,11). These buds are cyclically active, reflecting the cyclic pattern of carbohydrate reserve levels in the roots (10). Birdsfoot trefoil and crownvetch continuously produce new shoots from axillary buds and do not show a well-defined cycle of root reserves (4,10). Bud activation and shoot development appear to be influenced by light levels and endogenous growth regulators in both hay- and grazing-type legumes. Attempts to incorporate bud activity into alfalfa growth models have had limited success (3).

Rhizomatous or creeping-rooted alfalfas are more tolerant of continuous grazing than non-spreading types (6), but no comparisons of regrowth patterns have been reported. Grazing tolerance is not necessarily related to spreading, because relatively few plants may spread in solid stands (1).

We hope to determine some of the relationships among frequency, intensity, and pattern of herbage removal; number, location, and activity of regrowth sites; and carbohydrate and nitrogen reserves of non-spreading, spreading, and axillary branching alfalfas in a study just beginning at Cheyenne. Findings of this and similar studies may aid breeders to develop a true grazing-type alfalfa.

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# Interseeding Alfalfa for Grassland Improvement in the Northern Great Plains

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It is estimated that 70% of the native rangeland in the Northern Great Plains is in fair or poor condition. Native legumes and the most productive native grasses have been reduced in number and vigor. The loss of legumes has meant a reduction in available nitrogen. The development of pasture-type alfalfas offers a unique opportunity to increase the productivity of depleted rangeland. Alfalfa cultivars, such as Teton, Travois, and Rambler, have persisted well under continuous grazing in this environment. The challenge, now, is for the agronomist, range scientist, and rancher to incorporate pasture alfalfas into these less productive sites.

Interseeding is the technique by which a legume or a legume-grass mixture is planted into a permanent grassland with minimum tillage of the existing sod. The types of machines that have been used successfully vary considerably. A proven machine has been developed and tested by the South Dakota Agricultural Experiment Station. It has a coulter and slanted disk,which cuts and removes a strip of sod 4 to 6 inches wide and 2 to 3 inches deep. The spacing between the rows is 30 inches. A double-disk furrow opener is used to plant the alfalfa or grass mixture. Four rows are interseeded simultaneously,and a fertilizer attachment is used to supply phosphorus in the row at planting time. Seeding rates vary with the site, but 2 lb/acre of a pasture alfalfa and 4 lb/acre of perennial grass are recommended.

The addition of alfalfa to the native grassland increases both the quantity and quality of the herbage. In tests at the Pasture Research Center, Norbeck, South Dakota, forage production was increased 30-40% by interseeding native range. The crude protein content of the grass component between the alfalfa rows was increased 4 percentage units above the same grass untreated. Preliminary grazing experiments comparing native and interseeded native range have indicated a 35% gain in beef production per acre from interseeding Travois alfalfa into a predominantly cool-season grass sod. The fact that heavily grazed stands of Teton, Travois, and Rambler alfalfa are considerably better 5 years after interseeding can be attributed to the broad crowns or creeping growth habit of the alfalfas and their deep-set crowns. This improvement of interseeded alfalfa stands with time is a strong selling point in recommending this practice in the Northern Great Plains.

The success of interseeding depends upon the availability of moisture at planting and following seeding. Moisture conservation practices prior to interseeding may improve the chances of success, especially in the 15- to 16-inch rainfall areas. Preliminary experiments have been started using annual and perennial crop barriers to conserve moisture. Sunflowers and sorghum were used for annual barriers and tall wheatgrass for a perennial barrier. The barriers were planted at 40-foot intervals perpendicular to the prevailing winds in order to catch snow. The alfalfa or alfalfa-grass mixtures were seeded either in spring at the same time as the barriers, in fall, or the following spring. These moisture conservation systems for interseeding need to be evaluated further to determine their merits.

# Adaptation of Alfalfa and Other Forage Legumes to the Semiarid Environment of the Great Plains

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Research on legumes for dryland pastures and semiarid rangelands started in the United States in the early 1900's with the establishment of evaluation nurseries at several locations in the central and northern Great Plains. Unfortunately, these early efforts were discontinued a few years after they were initiated. In the late 1940's personnel of the Soil Conservation Service assembled and evaluated an extensive collection of legumes indigenous to the Great Plains and adjacent prairies. This project was terminated in the early 1950's.

Several researchers (1,2,3, and 4) have evaluated the suitability of native and introduced legumes for the improvement of rangelands at different locations in the Great Plains. In general, the native legumes were not suitable because of poor seed production characteristics and poor seedling vigor. Several introducted species have showed considerable promise at one or more locations. Generally, alfalfa performed the best and those lines having *Medicago falcata* parentage appeared to have the best overall adaptability. Cicer milkvetch performed well at some locations, but its seedling vigor and establishment characteristics were relatively poor. The performance of sainfoin has been erratic and it is best adapted to areas in Montana and southern Alberta. Several other species were reasonably well-adapted, but they contain poisonous compounds or produce very coarse, stemmy growth. In the central Great Plains the prospects for successful legumes culture are great for areas that receive 40 cm or more of annual precipitation, marginal for areas that receive 30 to 40 cm, and minimal for areas that receive less than 30 cm.

Little published information is available on the relative importance of various pests. In the drier regions diseases do not appear to be a major problem and grasshoppers are probably the most serious insect pest. Pocket gophers are very destructive to legume stands, and next to inadequate precipitation they are probably the most limiting factor in legume performance. Rhizomatous or creeping-rooted plants, however, tolerate gopher activity better than plants with a large taproot.

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# Recent Developments in Breeding a Bloat-safe Alfalfa Cultivar

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In this report we review recent progress toward our primary research objective, the development of a bloat-safe alfalfa cultivar.

A major development has been the formulation of the cell rupture hypothesis. This hypothesis emphasizes rupture of the leaf mesophyll cell wall as a key event in the occurrence of pasture bloat. The leaf proteins, which cause pasture bloat, are intracellular constituents and they cannot cause bloat until they have been released from the cell into the rumen fluid. Cell wall rupture results from mechanical damage during mastication and from microbial digestion. The experimental evidence for this hypothesis comes from comparisons of bloat-causing and bloat-safe legumes (1). The hypothesis suggests a new approach to breeding bloat-safe forage legumes; that is, the selection of plants which have greater resistance to mesophyll cell rupture.

In an earlier report (2) we suggested analysis for soluble protein as a screening method. In view of the cell rupture hypothesis, we have modified this procedure to give an indirect measure of cell wall rupture. In the modified procedure, the yield of soluble protein is inversely proportional to particle size of the sample. Hence the degree of fragmentation during grinding is reflected in the soluble protein yield. The average yield of soluble protein is approximately 50 percent. Among 560 entries in an open-pollinated progeny test, the range of extracted soluble protein was 9.66 to 11.02 g/100 g DW. It was gratifying to note that there were no obvious differences between the two extremes in nitrogen content, leafiness and time to flowering. New analytical techniques to give faster, more direct measures of cell wall properties are under evaluation.

The cell rupture hypothesis is not incompatible with the tannin hypothesis. Although alfalfa herbage does not contain tannins (flavolans), they are present in the seed coat. Thus alfalfa has the genetic capability for biosynthesis of tannins. We are presently screening an $M_2$ population from mutagen-treated seed with the hope of finding plants which contain tannins in the herbage.

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## Improving Alfalfa for Rangeland Use

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The requirements of an alfalfa generally adapted to rangeland are governed by certain restrictions. These include restrictions brought about by range condition and livestock management; by general ecological conditions: climatic, edaphic, and biological; by economic considerations such as seed availability and price; and by incidence of bloat. They also include plant physiological parameters: adaptability to drought or cold stress; damage by livestock and pests; and damage by chemicals and fire. However, improvement of these characteristics may be governed by the availability of alfalfa germplasm to extend the physiological parameters. Rangeland into which alfalfa is introduced can be either native or introduced species; it can be either cool- or warm-season grass species or both. Alfalfa selections may be compatible in different ways to these species. Though much has been done to improve the production of a general type alfalfa, we are still assessing the many specific requirements to determine the effect of both micro and macro environments on a rangeland type alfalfa. At the same time, we are breeding alfalfa to fill the needs peculiar to rangeland.

## Longevity of Alfalfa Seed

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Two-hundred twenty-eight lots of alfalfa (*Medicago* spp.) seed, ranging in age from 23 to 70 years (stored between 1906 and 1953) were tested for germination. A seed lot may represent plant introduction or open-pollinated seed from a single plant. The seed had been stored in unheated and uninsulated buildings at Belle Fourche, S.D., and Mandan, N.D. One *M. falcata* L. seed lot germinated 27 percent after 68 years and a second germinated 48 percent after 66 years of storage. For *M. sativa* L., one seed lot germinated 7 percent after 70 years while a second lot germinated 30 percent after 62 years of storage. *M. falcata*, in most instances, retained seed viability longer than did *M. sativa*. Samples of some of the older seed (1908-1915) were germinated by independent investigators in 1971 and 1976. Significant variation between seed lots harvested the same year suggests that seed longevity is genetically controlled. This idea is supported by wide differences in seed longevity of *M. sativa* and *M. falcata*. When germination percentage was regressed on years of storage by linear regression, a correlation coefficient of -0.95 and a regression coefficient of -2.23 were found for *M. sativa* and some of its hybrids. Coefficients were significant at a > .0001 probability level. Every year of storage between 30 to 70 years, presupposed a 2.23 percent decline in *M. sativa* seed germination.

## Environmental Effects on the Expression of Male Sterility in Alfalfa

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Cytoplasmic-genetic male sterility in alfalfa was characterized by incomplete pollen development or abortion of pollen grains after completion of meiosis. This cytoplasmic system was also characterized by various degrees of partial sterility(1,2,3). Pollen sterility in this male sterile system is changeable under different environments. Influences of growth temperature and light regime on the expression of male sterility were evaluated.

Male sterile and normal plants were grown under the two different temperature conditions(24/19°C and 15/15°C) and field condition. These materials were also grown under the two different light intensities(55,000 and 19,000 luxes) and the two different day lengths(18 and 13.5 hours).

Growth temperature affected greatly on the pollen sterility of not only male sterile plants but also normal plants. Pollen sterility under low temperature condition(15°C throughout 24 hours) was approximately 30 percent higher than that under high temperature condition(24°C in daytime, 19°C at hight) through these experiments. Highly significant interaction between plants and growth temperatures was found. Influence of growth temperature on pollen sterility seems to be greater for highly sterile plants than slightly sterile plants. Pollen sterility in the field was slightly higher than the average of pollen sterilities under the growth temperatures of 15/15°C and 24/19°C.

Highly significant difference of pollen sterilities under two light intensities suggested that light intensity also influenced the expression of pollen sterility. Mean pollen sterility under 19,000 luxes light intensity was 7.6 % higher than that under 55,000 luxes light intensity. Magnitude of the influence of light intensity was much smaller than that of growth temperature.

On the other hand, there was no significant difference between the pollen sterilities under 18 hours and 13.5 hours day lengths.

Pollen sterility in cytoplasmic male sterile alfalfa is controlled by genetic system, however, it is influenced by environmental factors such as growth temperature and light intensity. Evaluation for pollen sterility should be carried out with the consideration of these factors and the inheritance system of male sterility should be studied under the regulated environment to reduce the complexity of genetic factors and environmental factors.

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## Contamination on Contiguous Borders in Alfalfa Seed Production Fields

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Spacial isolation problems pertaining to the production of certified seed continue to increase as new cultivars of alfalfa are developed and few are withdrawn from production. For over 12 years, alfalfa breeders and regulatory people have wrestled with a reexamination of empirical isolation standards. Previous crossing studies used primarily recessive flower color differences in small plantings of less than 5 acres. This study was initiated to determine contamination levels along contiguous borders between cultivars with contrasting disease and insect resistance.

Two field situations were selected: (1) a one-fourth mile contiguous border between two 25 acre fields planted to Saranac AR and MS4, differing in anthracnose resistance; (2) a 640 foot contiguous border between two 10 acre fields of Dawson and Iroquois, differing in pea aphid and spotted alfalfa aphid resistance. Leafcutter bees were the pollinators.

Seed samples were taken at seven distances (0, 5, 10, 20, 40, 80, and 160 feet) perpendicular to the contiguous border at four locations along the border in each of four cultivars. Three seed lots served as standard measures of performance in each case, a foundation lot from the breeder, a sample of the certified seed from the center of the field, and a hand intercross between the two varieties.

Evidence for crossing along the contiguous border was lacking. Close examination of the first three distances, where one would expect the most crossing based on previous studies, showed values very similar to the certified sample from the field and distinct from the corresponding distance on the opposite side of the border. This is in direct contrast to flower color studies conducted in much smaller fields. Of 56 samples tested only two significant departures from expected levels of resistance were noted in the anthracnose study, two in the pea aphid and one in the spotted aphid test. Although we concede that these departures may have been due to cultivar crossing, it appears from the random placement that sampling variation arising from variation in genotypic frequencies at a given sample point could have caused the differences observed. The data support the idea that 0 isolation at the certified seed level would be practical for seed production in fields larger than 5 acres without destroying the phenotypic integrity of the cultivar.

Additional studies along contiguous borders using honey bees or alkali bees with variety differences involving hardiness and simply inherited traits may help to find a practical answer to the isolation problem beyond the applications of this study.

# Field Performance of 12 Strains of Rhizobium on 4 Alfalfa Varieties 1/

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Seed of the 4 current forage yield check varieties in the North Central Region of the USA was inoculated with 12 Rhizobium meliloti strains and planted in field plots at the Mead Field Station, Mead, Nebraska. The seed lots were 'Dawson' DCC72, 'Kanza' KCC72, 'Saranac' SCC72, and 'Vernal' VCC72. The strains were effective on alfalfa varieties in previous laboratory and field tests. The Pelinoc system was used to inoculate seed April 20, 1976, and the experiment was seeded April 21-22, 1976.

The soil type is Sharpsburg silty-clay loam. Lime and phosphate were applied according to soil test recommendations. However, more than a year after application and after seeding the experiment, the lime was found to be inferior. The soil pH was 5.6 with a buffer pH of 6.2. Other nutrient levels were 51 ppm P and 402 ppm K. No alfalfa had been seeded on the site from 1963 to 1976 and the previous cropping history was unknown. A randomized block split-plot design was used with 3 replications each for forage yield and for observations. A single plot consisted of 5 rows 15' in length with 6" between rows and 12" between plots. Compressed air was used to clean the drill between plots.

In the year of seeding, percent stand differed among varieties, percentage of nodulated plants differed among strains, and both varieties and strains differed in first cutting forage yield and nitrogen content. Stands varied from 86 to 94% for varieties averaged over strains. The percentage of nodulated plants varied from 52 to 75% for strains averaged over varieties, compared with 18% for uninoculated plots. Forage yields and nitrogen contents of forage from Saranac and Vernal were equal and higher than that of Dawson and Kanza which were similar. Forage yields varied from 1.01 to 1.16 tons/acre (dry matter) for strains averaged over varieties, compared with 1.07 tons/acre for the uninoculated plots. Nitrogen contents of the forage varied from 2.48 to 2.66% for strains averaged over varieties, compared with 2.53% for the uninoculated plots. Yield and quality were not determined in subsequent cuttings.

In 1977, total season forage yields from 4 cuttings differed among varieties. Yields of Dawson, Kanza, and Vernal were in the same range. Kanza and Saranac differed in yield. Percent stand differed among strains in July, although stands varied from 85 to 90%.

Variety x Rhizobium strain interaction was not significant for traits measured in 1976 and 1977.

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# Field Performance of Rhizobium Inoculation Methods on Two Alfalfa Varieties 1/

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Two Rhizobium inoculation method studies were conducted on two varieties, Dawson and Gladiator, at the Mead Field Laboratory, Mead, Nebraska. Conventional peat inoculation was compared with the CelPril, Noculized, Noculimed, and Pelinoc inoculation methods. Each year, one seed lot of a variety was used for all inoculation methods in cooperation with industry. The soil type was Sharpsburg silty clay loam. The same preplant herbicide was used each year. All seeding rates were 12 pounds of viable seed/acre.

The site of the April 1976 seeding had a soil pH of 5.6 and a buffer pH of 6.2, with 51 ppm P and 402 ppm K. No alfalfa had been seeded from 1963 to 1976 and the previous cropping history was unknown. A randomized block design with 3 replications was used. A single plot consisted of 4 rows 15' in length with 6" between rows and 12" between plots. Differences among inoculation methods were not significant for forage yield in the first cutting, percentage of inoculated plants in July, and for stand establishment in September of the year of seeding. From 23 to 51% of the plants were nodulated, stands varied from 87 to 92%, and forage yields varied from 1.05 to 1.63 tons/acre dry matter.

The site of the April 1977 seeding had a pH of 6.8 and a buffer pH of 7.0, with 31 ppm P and 455 ppm K. Alfalfa grew on the site from 1968-72, followed by soybeans and sorghum. Rhizobia for the CelPril treatment were an equal numbers blend of two strains highly effective in nitrogen fixation on Dawson in the laboratory. A randomized block design was used with 4 replications each for forage yield and for observations. A single plot consisted of 5 rows 15' in length with 6" between rows and 12" between plots. In the year of seeding, differences among inoculation methods were not significant for total season forage yield from three cuttings. Differences among inoculation methods were not significant for protein contents in the first and third cuttings, stand establishment in July, stand counts in July and August, plant height and percentage of inoculated plants in June. Total season forage yields varied from 2.80 to 3.09 tons/acre dry matter; protein contents varied from 19.4 to 20.4% in the first cutting and from 20.9 to 21.7% in the second cutting; stands varied from 98 to 100% in July, and from 78 to 95% of the plants were nodulated.

Results in the year of seeding from two field experiments with two varieties under both favorable and unfavorable pH but high P and K conditions, showed no advantages for inoculated (including CelPril, Noculized, Noculimed, and Pelinoc methods) over uninoculated seed for stand establishment, forage yield and quality when seeded at twelve pounds/acre.

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# Response from Selection in Alfalfa for Factors Associated with Nitrogen Fixation

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Most efforts to improve nitrogen fixation in alfalfa (*Medicago sativa* L.) have been to improve the effectiveness of *Rhizobium meliloti* Dang. strains, but recently increased attention has been devoted to studying the plant's role in the symbiotic relationship. Seetin and Barnes (1) reported that acetylene reduction rates (AR) and some associated morphological characters were heritable in greenhouse cultured alfalfa plants. The objectives of this research were to determine 1) if progress could be made by breeding alfalfa for AR and some associated characters and 2) which associated characters would be the best selection criteria for improving AR and forage yield.

Two cycles of simple recurrent mass selection were conducted using MnNC-4, a genetically broad-based population, in low-nitrate greenhouse sand culture. MnNC-4 was divided into subpopulations for bidirectional selection for AR per plant, top dry weight, nodule mass score, and fibrous root score. Responses to selection were determined by simultaneously evaluating plants from the original population and from selection cycles 1 and 2 in the greenhouse.

Subpopulations responded significantly to selection in both directions for each of the criteria. Two cycles of selection improved AR by 70% and top dry weight by 65% over the original population. Based on a five-class scoring system (1 = lowest amount, 5 = greatest) mean nodule mass score increased from 3.2 to 3.9 and mean fibrous root mass score increased from 2.7 to 3.8. The rates of progress per cycle of selection were about equal for all criteria selected in the high direction.

After two cycles of selection, the morphological characters selected in the high direction improved mean AR of the subpopulations about equal to selecting for AR *per se*. However, selection for the morphological characters resulted in subpopulations with lower medians than those selected for AR, indicating different types of responses. All the criteria except fibrous roots improved top dry weights, but the greatest response was from selection for top dry weights *per se*, followed by selection for high AR and high nodule mass.

All the characters studied were positively and significantly correlated in all combinations, but individual plant data suggested some independence among characters. Of the characters studied, nodule mass score accounted for the most variability due to AR. Coefficients of determination were .42 for nodule mass score, .03 for nodule number score, .03 for top dry weight, .02 for fibrous root score, and .00 for secondary root score. The efficiency of the symbiotic relationship probably explains most of the remaining variation due to AR. Therefore, we believe that selecting for AR after selecting the largest plants with the largest nodule mass will most efficiently improve AR and ultimately nitrogen fixation.

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# Growth of Shoots and Roots of Alfalfa and Red Clover in Controlled Environments

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The use of the slant-board technique for classifying plant genotypes and cultivars for root characteristics was evaluated in this study. Seeds of alfalfa (*Medicago sativa* L.), 'Saranac,' 'Moapa,' and 'Victoria,' and red clover (*Trifolium pratense* L.), 'Kenland,' 'Kenstar,' 'Pennscott,' and 'Arlington' were germinated in cups of vermiculite. At 2 weeks of age, the seedlings were transplanted to slant-boards as described by Kendall and Leath (1974). Seed lots were started at weekly intervals and five plants were placed on each board with six boards per cultivar. The plants were cut and weighed at 3-week intervals. Daylengths of 13 and 18 hrs were used during the growth periods that preceded the first three and last three cuts, respectively. At each cutting date, the tops of the plants were cut off at 5 cm above the junction of the top and root, and the roots were cut off at 5 cm below the same junction. Fresh weights were obtained for each section of the plant and then the crowns were returned to the slant-boards. After the sixth harvest, the plants were incubated in the dark until 50% of the etiolated topgrowth lost turgidity.

At the first cutting date, which provided an estimate of seedling vigor, plants of Moapa and Kenland were relatively small, and plants of Victoria were large. Plants of Kenland, Saranac, and Moapa were more taprooted than were plants of other cultivars. Moapa plants had small tops and large roots, whereas plants of Kenstar and Victoria had large tops and small roots.

The major differences among cultivars at the sixth harvest (full-bloom stage) were as follows: small tops for Saranac, large roots for Pennscott, longer roots for alfalfa than red clover, more taprooted types among alfalfa than red clover cultivars, high shoot/root ratios for Arlington, and a low shoot/root ratio for Saranac.

During the incubation in the dark, the alfalfa plants persisted longer than the clover. Topgrowth in the dark was relatively large for Saranac and Pennscott and small for Moapa. Root elongation in the dark was extensive for alfalfa plants and practically nil for clover plants.

Differences in root growth within and between cultivars was obtained with the slant-board technique. Rankings of cultivars were not the same for plants in the seedling and flowering stages of growth.

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# Nematode Resistant Alfalfa In Crop Rotations for Root-knot Nematode Control

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The cost of nematicides and their application, as well as their environmental impact, including their effect on the total soil microflora, are some of the reasons that methods of nematode control other than chemical have been gaining in popularity. Crop rotation has been used to manage nematode populations under field conditions. Rotations involving non-host and resistant crops offer several benefits over other methods. Alfalfa has been sucessfully used in rotations in the West because it provides a cash revenue in addition to soil amendment benefits. Where root-knot nematodes, especially Northern root-knot nematode (*Meloidogyne hapla* Chitwood), are a problem nematode susceptible alfalfa will generally aggrevate the problem because nematode populations increase rapidly on susceptible alfalfa. A completely resistant alfalfa has the potential of reducing these nematode populations to a level low enough to enable a susceptible crop to be grown without nematicides or with a significantly reduced nematicide application.

Host resistance to *M. hapla* was developed in a hardy alfalfa germplasm and to *M. hapla* and to Southern root-knot nematode (*M. incognita* Kofoid and White) in a non-hardy alfalfa germplasm through a program of genetic selection (1). The resistant, hardy alfalfa population, designated Nevada Synthetic XX (2), has shown no segregation for susceptibility to *M. hapla*.

Results of small plot studies conducted at Reno, Nevada, indicate that Nevada Synthetic XX alfalfa, seeded into heavily infested soil (600± nematodes/100 cc soil), is capable of reducing the nematode population to a level at which virtually no galling 0.8 galls/plant) occurred on assay tomatoes grown in soil sampled from these plots 12 months after the resistant alfalfa was established. Tomatoes grown in soil from plots of susceptible alfalfa had over 200 nematode galls per plant.

Further studies were conducted in which the level of nematode resistance in the alfalfa seeded to nematode infested plots was mechanically varied from 0 to 100% resistance. This study indicated that satisfactory control of the nematode population required resistance levels above 70%.

A pilot test program on large field plots has been initiated in three western states to determine the effectiveness of nematode resistant alfalfa in controlling nematode populations when grown in rotation with nematode susceptible crops.

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# Rhizosphere Problems Limiting Alfalfa Production in the 'Deep South'

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Alfalfa is grown on a very limited hectarage in the Southeast. Most alfalfa is grown on the heavier soils of the Piedmont plateau in the 'Upper South' or on a narrow band of calcareous soils called the Black Belt. Alfalfa production on the light textured soils of the Coastal Plains is limited by several severe rhizosphere problems. These include high soil temperatures, periodic droughts, hardpans, subsoil acidity and high pathogen loads.

Research at Auburn is concentrating on determining what organisms are involved in the pathogen complex. The following species of fungi and nematodes have been associated with alfalfa grown in Alabama.

| Fungi | Nematodes |
|---|---|
| *Fusarium solani* | Root Knot-----*Meloidogyne* sp. |
| *F. oxysporum* | Lesion--------*Pratylenchus* sp. |
| *F. moniliforme* | Ring----------*Criconemoides* sp. |
| *F. semitectum* | Dagger--------*Xiphenema* sp. |
| *F. lateritium* | Stunt---------*Tylenchorhynchus* sp. |
| *Rhizoctonia solani* | Stubby Root---*Trichodorus* sp. |
| *Pythium* sp. | Spiral--------*Helicotylenchus* sp. |
| *Cylindrocladium* sp. | Lance---------*Hoplolaimus* sp. |
| *Sclerotium rolfsii* | |
| *Curvularia affinis* | |
| *Sclerotinia trifoliorum* | |
| *Phytophthora* sp. | |

The most commonly occurring fungi found in Central Alabama include the *Fusarium* sp., *Rhizoctonia solani* and *Pythium* sp. An initial evaluation of *Rhizoctonia solani* isolates showed 9 out of 14 were highly pathogenic. *Pythium* isolates were also found to be pathogenic. Greenhouse techniques are being used to further characterize the pathogenicity of several species of fungi thought to be involved in the pathogen complex on alfalfa.

The nematode genera listed above are associated with root damage on alfalfa. The root pruning nemas such as stunt and stubby root are particularly severe pathogens. A screening program has been initiated to improve the tolerance of alfalfa to the root pruning nematodes.

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# Aphelenchus avenae as a Potential Biological Control Agent for Control of Fungi Causing Root and Crown Rots of Alfalfa

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Root and crown rots are a problem in alfalfa production and are difficult to control. There are no formulations of soil fungicides that are approved by EPA for use in alfalfa soils. There are several cultivars resistant to *Phytophthora* root rot, but there are none available that are resistant to *Rhizoctonia solani*, *Pythium* spp. and *Fusarium* spp. A soil treatment that will control a wide spectrum of soil-borne plant pathogenic fungi, particularly before seeding, is needed. Fungicides are usually restricted in their activity and tend to leave undesirable residues in soil and sometimes in the subsequent crop.

Biological control is a desirable component of any integrated pest management system. We are conducting research to determine the feasibility of using antagonistic fungi, antagonistic bacteria and a mycophagous nematode, *Aphelenchus avenae*, for control of pathogenic fungi. We have found this nematode to be non-pathogenic to alfalfa (unpublished) and it has a very wide fungal host range, including most of the soil-borne plant pathogens. Literature on fungal control potential is scant and scattered. These publications report control of *R. solani*, a *Pythium* sp. and *Fusarium* spp. We have obtained control with isolates of *R. solani* and *Fusarium* sp. pathogenic to alfalfa.

In greenhouse tests, Cody seedlings were planted in 15.2 cm (6 in.) clay pots of soil, containing measured amounts of *A. avenae* and fungus inoculum (*R. solani* or *Fusarium* sp.) and in corresponding check pots, after a 3-week "interaction" period. One month later, numbers and condition of surviving plants were obtained. Though preliminary data is variable, it shows that populations of 125,000 to 1 million *A. avenae* per pot provides high survival rates of non-stunted plants with healthy roots. Any survivors in pots containing only a fungus pathogen were usually stunted, chlorotic and had damaged roots.

*Approved as a Professional Paper by the Director of the Oklahoma Agricultural Experiment Station, Oklahoma State University, Stillwater.

# The Past, Present, and Future of Alfalfa Research in Alaska

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The potential value of alfalfa to forage production was well recognized by early agricultural researchers conducting a pioneer program to determine what would grow in "Seward's Folly". Successful alfalfa research in Alaska was initiated at the Rampart Experiment Station, where Medicago falcata, SPI 24452, first seeded in 1909, exhibited outstanding winter survival, in contrast to near failure for M. sativa. While this M. falcata was increased for several years at Rampart, problems of slow establishment, low forage productivity, low seed set, and seed shattering received prominent mention. As the currently operational Experiment Stations at Fairbanks and Palmer were opened (and Rampart closed) similar patterns of low survival of M. sativa were recorded. When agricultural research entered a dormant period in the late 1920's only M. falcata was considered adapted to Alaska.

The revival of active agricultural research in Alaska in 1948 also marked a modest expansion of alfalfa investigations. Recognized shortcomings of the Alaska M. falcata population were attacked through selection in spaced-plant nurseries, with minimal accomplishment. Attempted crosses of M. falcata with M. sativa revealed that this M. falcata was diploid; a few seeds, attributed to unreduced eggs, were obtained. A tetraploid hybrid population, A-syn.A, was produced by backcrossing this material to doubled M. falcata. In the meantime, encouraging improvement in winter survival of M. sativa was recorded following repeated recombination of surviving plants, leading to the development of A-syn.B and A-syn.C populations at Fairbanks and Palmer, respectively. A-syn.B has an unknown, probably broad, gene base; plants were originally selected from several old plantings. A-syn.C originated as near equal plant numbers from Vernal and Narragansett. Plants selected from sub-populations of A-syn.B, following additional natural selection at Palmer, form the parental stock of a new cultivar, 'Denali'.

A realignment of research assignments in Alaska includes the allotment of additional resources to forage research, starting in 1978. The encouraging performance of alfalfa materials, developed with minimum support, and the potential of this crop in forage agriculture, suggests that alfalfa receive primary attention from this expanded effort. Current status of alfalfa will be assessed through the extensive testing of Denali in farm trials, to determine whether this variety can compete and contribute significantly in perennial forage production as a viable alternative to the current practice of heavily fertilized grass monoculture. Management options for the enhancement of alfalfa in grass-legume or single crop legume forage production at a competitive cost to current systems will receive attention. Finally, breeding nurseries are currently being expanded, designed to provide basic plant materials for the development of new combinations of genetically diverse, winterhardy, productive, alfalfa for Alaska.

# Aluminum-Tolerant Alfalfa — Status for 1978

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Aluminum toxicity in acid subsoils is believed by soil scientists to be a major factor limiting alfalfa production in many parts of the Eastern United States, particularly in the Southeast. Alfalfa is normally a deep-rooted crop capable of utilizing both moisture and minerals in the lower soil. However, where toxic levels of Al occur in acid subsoils, effective rooting is prevented and alfalfa production is disappointing. Since liming of the surface soils has little effect on the acidity of the subsoils, development of Al-tolerant alfalfa is needed.

In 1973, screening for tolerance to acid, Al-toxic soil conditions began at Beltsville. Arc-related germplasm was selected as the parent population. Subsequently, four cycles of screening for Al tolerance have occurred, two in acid, Al-toxic soil and two in nutrient culture adjusted to pH 4.2-4.5 with 3 ppm Al.

Following the four cycles of screening, an evaluation of the progress of our screening efforts was conducted using the nutrient solution culture technique. Entries included the original Arc population, Cycles 1, 2, 3, and 4, and Williamsburg as a check. Results indicated that when grown for 5 weeks at pH 4.2-4.5 with 3 ppm Al, plant heights and top weights of Al-tolerant Cycle 4 seedlings were 67 and 86% greater than those of Arc. Seedling growth of Williamsburg was poorer than Arc.

Following harvest, plant tops and roots from each entry were ground and analyzed for 13 mineral elements including Al. Aluminum concentration in the roots was considerably greater than in the plant tops (2792 vs. 89 $\mu g/g$). Apparently the bulk of the Al is trapped in the roots. No significant difference in Al concentration in the plant tops was observed among entries. However, Al concentration in the roots of Arc and the four cycles of selection was significantly higher than for Williamsburg.

In another study, we compared in Al-toxic nutrient culture the relative performance of the Al-tolerant Cycle 3 seedlings with that of 27 cultivars chosen to represent U.S. alfalfa-growing areas. Aluminum tolerance was not found in any of the 27 cultivars regardless of their area of adaptation. Plant heights and top weights of the Al-tolerant Cycle 3 seedlings were 41 and 110% greater than the best cultivar tested.

# Fall Dormancy in Alfalfa: A Valuable Predictive Tool

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During the last 20 years fall growth scores of alfalfa cultivars have been observed each October at Rosemount, Minnesota. Our procedure has been to establish space-plant nurseries either by direct seeding in early May or by transplanting 9-week-old plants in mid-June. Spacing between rows is approximately 0.7 m with 30 cm between plants within rows. Each entry is planted in four (replications) single row plots with 25 plants per plot. Plots are clipped once during mid-July and then again September 8. About October 13, each plant is scored for plant height on a 1-9 scale; 1 = >40 cm, 2 = 35-40 cm, 3 = 30-35 cm, ---------- 9 = 0-5 cm.

Six cultivars, representing a complete range of fall dormancy responses, have been included each year as standards. The cultivars and their 11-year average fall growth scores are African (nondormant) = 3.6, DuPuits = 5.0, Saranac = 6.1, Vernal = 7.1, and Norseman (very dormant) = 8.1. The relative rank of the six cultivars was consistent over all test years.

Fall growth scores are useful because they are closely correlated with winter injury scores the subsequent spring[1]. In three years where significant winter injury occurred, the winter injury score was significantly correlated with the previous fall growth scores (r = .95, .90, and .84). Since winter injury does not occur every year we have used the fall growth score to predict winterhardiness and cultivar adaptation. In Minnesota the most productive cultivars tend to have fall dormancy scores similar to Ranger.

Data collected during 11 years were used to determine the relative importance of environmental factors on fall growth response. Low temperatures and photoperiods less than 12 hours appeared to be the most critical environmental factors. This agrees with earlier reports about fall dormancy responses in alfalfa. Because of the consistency of fall dormancy evaluations in Minnesota we believe that information from this type of evaluation has the potential to be a valuable descriptive tool for alfalfa breeders. A comprehensive study needs to be conducted to establish the relationship between fall dormancy responses in Minnesota and fall dormancy responses at other locations. It should then be possible to define what environmental limitations need to be placed on fall dormancy data used to describe cultivars in the United States.

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# The Role of Heterozygosity in Alfalfa Yield: Report of 10 Years of Research

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Achieving maximum heterozygosity (heterosis) in autotetraploid crops such as alfalfa is much more difficult than in diploid crops. This is because autotetraploids potentially may have four different alleles at a locus (indistinguishable from four different blocks of linked genes) as compared to only two alleles in a diploid. Moreover, in autotetraploids the frequency of tetra-allelic loci increases from the single cross (e.g. 44%) to the double cross generation (e.g. 79%) using inbreds or partial inbreds and normal sexual reproduction. In diploids it can essentially reach 100% in a single cross of two different inbreds.

Our interest in the concept of maximum heterozygosity began about 20 years ago when M. W. Pedersen called our attention to the work in progress by Y. Demarly in France. Following this, H. L. Carnahan suggested at the 17th NAIC conference that four different alleles at a locus were needed for maximum heterozygosity. In 1963 Demarly's work was published and in 1966, Busbice and Wilsie published research on inbreeding depression which was pertinent to the concept. Inbreeding depression in alfalfa is greater than can be explained on the basis of homozygosity and Busbice and Wilsie suggested that the rapid inbreeding depression was similar to the theoretical rate at which first-order interactions were lost from tri- and tetra-allelic loci.

About 1968 cultivated diploids were obtained by haploidizing tetraploids. Several of these diploids were crossed with unrelated diploids and the hybrid (heterozygous) progeny were colchicine doubled to produce autotetraploids. Since heterozygous loci in these tetraploids could be only di-allelic duplex they constituted a defined set of parents to test the concept of maximum heterozygosity. It can be shown that when four or more different alleles are represented in a set of such parents, their single cross (SC) progeny possess 11.1% di-allelic duplex, 44.4% tri-allelic, and 44.4% tetra-allelic loci. Mating SC plants to produce double crosses (DC) results in 1.2% di-allelic duplex, 19.8% tri-allelic and 79% tetra-allelic loci. The SC generation is similar to a Syn. 1 and DC similar to the Syn. 2 generation. Further generations of synthesis result in a decrease in the frequency of tri- and tetra-allelic loci.

Thus, heterozygosity is maximum at about 80% tetra-allelic loci in the DC or Syn. 2 generation. In an experiment using di-allelic duplex parents to produce SC and DC combinations the actual results were in complete agreement with the theory (Dunbier and Bingham 1975). DC yields were greater than SC for both herbage (7% DC>SC) and seed (37% DC>SC). Additional evidence confirming both the existence and importance of tri- and tetra-allelic interactions in alfalfa vigor and yield is as follows:

- DC yields of herbage and seed were once again greater than SC yields in a follow-up experiment using a new set of diallelic duplex parents.

- Self fertility of DC plants was significantly greater than that of SC plants in two separate experiments.

- Herbage yields of synthetics derived from single DC plants were significantly greater than yields of those from single SC plants.

- Tetra-allelic tetraploids produced by restitution gametes from diploid parents produced twice as much herbage and 1000 times more selfed seed than defined di-allelic duplex tetraploids from the same diploid parents.

- Di-allelic duplex autotetraploids derived from self-fertile cultivated diploids were essentially self-sterile indicating that presence of only two alleles at a locus had a "crippling effect" on autotetraploid self-fertility.

- Finally, first division restitution gametes from a diploid (expected to be 100% heterozygous from the centromere to the first crossover) were found to produce tetraploid hybrids which were superior to hybrids produced by normal sexual gametes from the isogenic autotetraploids (expected to be 67% heterozygous).

Thus, the importance of intra-allelic interactions of tri- and tetra-allelic loci was verified in a number of experiments. Importantly, there were no exceptions. These results, related results in the literature, and much practical experience suggest that breeding procedures which minimize inbreeding and maximize tetra-allelic interactions are required for maximum alfalfa yields.

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## Alfalfa Protein Concentrate in Relation to Variety and Growth Stage [1/]

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Seed of the alfalfa (*Medicago sativa* L.) varieties Dawson,' 'Kanza,' 'Team,' and 'Weevlchek' was planted in field plots at the Mead Field Laboratory, Mead, Nebraska, in 1972. Forage of the varieties was harvested and sampled at three growth stages (bud, 1/10 bloom, and full bloom), in the first and second cuttings of 1973. Forage samples were used for chemical analyses of fresh hay, pressing juice, protein extraction, and subsequent chemical analyses. The purposes of the study were to determine the yield of alfalfa protein concentrate (APC) from four varieties at three growth stages, and to determine the recovery and chemical contents in processed forage residue.

The varieties did not differ in dry matter, protein, and carotene contents of fresh hay at any growth stage in either the first or second cutting. The percentage of protein in APC's did not differ among varieties at any growth stage in either cutting and averaged 76%. Forage and APC yields differed among varieties. The lowest forage and APC yields were obtained from Kanza. About 1% of the fresh weight of alfalfa was recovered as APC. APC yields averaged about 200 kg/ha over varieties and cuttings. APC recovery percentages differed among varieties and the lowest recovery was from Kanza. Protein recovery decreased as physiologic maturity increased.

At 1/10 bloom, average protein content of fresh hay was 18.6% compared with 16.4% protein in the residue after pressing (juice extraction), a 12% reduction in processing. Average carotene content of fresh hay was 190 mg/kg, and carotene content of the residue was 145 mg/kg at 1/10 bloom, a 24% reduction in processing.

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## Some Interesting Alfalfa Fungi

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During 1976 and 1977 numerous isolations were made from diseased alfalfa plants. Three of the fungal isolates appeared to be rare or new in the United States and possible factors in the depletion of alfalfa stands. Various structures of the microorganisms were illustrated in the poster session. Symptoms were depicted for two of these fungi.

Verticillium wilt, caused by *Verticillium albo-atrum* Reinke & Berth., was reported for the first time in the United States in 1976 in the Northwest. Conidia are borne singly at the apices of conidiogenous cells (type of conidiophore), and the conidiogenous cells are arranged in whorls. Disease symptoms include rapid wilting and dying of leaves, often while the stems remain green. The fungus produces a downy growth at the base of stems (rarely seen in nature). In cross section a brown ring is evident in the vascular tissue of the root.

A second fungus, unidentified as yet, was recovered from a diseased alfalfa crown in Maryland. The internal discoloration is similar to that caused by Colletotrichum trifolii Bain, but closer observation revealed small black bulbils (sclerotial-like bodies) among the woody tissues. The bulbils consist of clumps of rounded cells that later become melanized. Development of the bulbils and their presence in crown tissues has been observed. The fungus does not grow on potato dextrose agar. On V8-juice agar it produces only mycelium. But on corn meal agar the fungus produces both black mycelial strands and bulbils.

A third fungus has been isolated several times from brown necrotic streaks in the core of alfalfa roots in Maryland. The fungus is tentatively identified as Pyrenochaeta terrestris (Hans.) Gorenz et al., which has been reported on alfalfa in Canada and Hungary. It differs from Phoma in that the pycnidia are covered with long black hairs or spines. In preliminary pathogenicity studies in the greenhouse the fungus appears to be a slow root-rotter.

## Experimental Evidence for the Cell Rupture Hypothesis

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The cell rupture hypothesis (1) provides an explanation for differences in the bloat potential among various legume forages. The experimental basis for this hypothesis has come from comparative studies of three bloat-causing legumes (alfalfa, red clover and white clover) and three bloat-safe legumes (birdsfoot trefoil, cicer milkvetch and sainfoin). These species exhibited a wide range of variation in susceptibility to mechanical disruption and to digestion by rumen micro-organisms.

The original studies on mechanical disruption of leaves in a mortar and pestle have been published (2). Subsequently, similar results have been obtained by shaking leaves in a tube containing glass beads and buffer. The degree of tissue disruption observed in these experiments could have been due, in part, to species differences in epidermal layer or in structural tissue around the vascular bundles. Therefore, mesophyll cells were isolated from alfalfa, birdsfoot trefoil, cicer milkvetch and sainfoin and the isolated cells were disrupted by sonication. Alfalfa cells were the most susceptible to rupture by sonication and sainfoin cells were least susceptible. The conclusion from these studies is that leaf tissue and mesophyll cells from bloat-causing legumes are more susceptible to mechanical disruption compared to bloat-safe legumes.

Studies on digestion by rumen micro-organisms have been carried out by three experimental approaches: (a) digestion of whole leaves in vitro, (b) digestion of whole or macerated leaves in vivo in nylon bags, and (c) the concentrations of soluble leaf proteins and chlorophyll in rumen fluid of sheep fed alfalfa, birdsfoot trefoil, cicer milkvetch or sainfoin. Results were similar for all three approaches, i.e., leaves from bloat-causing legumes were digested more rapidly than leaves from bloat-safe legumes.

Although the cell rupture hypothesis was developed as an alternative to the tannin hypothesis of bloat prevention in certain legumes, the two hypotheses are complementary, and both probably contribute to the prevention of bloat in animals grazing sainfoin or birdsfoot trefoil. An attractive feature of the cell rupture hypothesis is that it may also account, in part, for the greater risk of pasture bloat during periods of rain, heavy dew, cool overnight temperatures and rapid growth of immature forage.

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## Alfalfa in Winter Pastures for Beef Cow/Calf Programs


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Grasses have been successfully used in wintering programs for beef cows in midwestern United States for many years in systems of field-stored round bales and fall-saved regrowth. The grass best adapted to such winter programs in terms of yield, persistence and quality has been tall fescue. Since 1973 legumes have been evaluated as tall fescue-legume mixtures in winter programs for beef cows in Ohio. The legumes are being used to eliminate or reduce the need for nitrogen fertilizer and to improve the forage quality.

Vernal alfalfa and Ky. 31 tall fescue winter pastures were established in 1973 at the Jackson Branch in southeastern Ohio. Two and three crops of hay harvested as large round bales (av. 480 kg) were field stored for the winter-feeding period, late October to mid-April. Cows and fall-born (August-September) calves were wintered for 4 years (1974-1978). The combination of hay and fall-regrowth yield was generally similar to that of tall fescue fertilized annually with nitrogen at 150 kg/ha. Where soil drainage is reasonably good, the alfalfa has persisted satisfactorily through four winters of animal utilization. Animal response in terms of spring calf weights and grades, cow weights and condition scores and cow reproductive performance has been excellent.

# Alfalfa Dinitrogen Fixation in the Field Measured by N-15 Incorporation

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Field experiments were initiated with the N-15 tracer technique to evaluate differences in dinitrogen fixation among 20 alfalfa clones, to compare dinitrogen fixation of two elite populations with a standard alfalfa variety, and to compare dinitrogen fixation of alfalfa, red clover, and birdsfoot trefoil. The clones previously had been selected for dinitrogen fixation capacity with greenhouse assays of acetylene reduction rate, nodule abundance, fiberous root development, and plant vigor. The two elite populations were developed by one cycle of recurrent selection for the listed characteristics. Mass spectrometric analysis of N-15 in herbage at first harvest 7 weeks after planting revealed that the poorest clones fixed no N, while the best acquired about 50% of their total N from symbiosis. On an area basis, dinitrogen fixation ranged from 0 to 53 kg/ha/7 wk. By second harvest, 11 weeks after planting, the poorest clones had obtained about 50% of the N fixed in the preceding 4 weeks from symbiosis, while the best clones had derived about 80% of their N supply from symbiosis. In the interval preceding second harvest, dinitrogen fixation among the clones ranged from 15 to 157 kg/ha/4 wk.

Analyses of N-15 in entire plants revealed that the elite populations had derived about 24% of their N from symbiosis by first harvest, compared with 8% by the variety 'Saranac.' Between first and second harvest, the elite populations obtained 65% of their N supply from symbiosis, compared with 56% for Saranac. On an area basis, the elite populations fixed 362 kg/ha N in 11 weeks, compared with 223 kg/ha for Saranac. These results support the hypothesis that dinitrogen fixation by alfalfa is a physiological trait amenable to genetic improvement by host selection.

For comparisons of dinitrogen fixation at first harvest among species in the seeding year, alfalfa and birdsfoot trefoil were sampled on July 12-14 and red clover on July 26-27, 1977. Dinitrogen fixation of red clover and alfalfa exceeded that of birdsfoot trefoil by 160 to 200%, respectively. Dinitrogen fixation of the later-harvested red clover averaged about 8% more than that of two alfalfa varieties. A close association of yield and dinitrogen fixation was observed among the three forage legumes. The alfalfas and red clover derived between 44 and 51% of their total N needs from symbiosis, whereas birdsfoot trefoil acquired only 27%. This result is reminiscent of the classical work of Allos and Bartholomew (1955), and it suggests major differences in dinitrogen fixation efficiency among forage legumes.

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# Some Chemical and Physical Observations on Alfalfa Genotypes Resistant to *Uromyces striatus*

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After being evaluated for resistance to leaf rust (*Uromyces striatus*), a total of 14 highly resistant or susceptible alfalfa plants were selected from MSB-11 and Moapa 69. The plants were grown in the greenhouse or a growth chamber to late bud or early flower stages. Some of these plants were inoculated with *U. striatus* spores. Leaf samples were inoculated and control plants were removed for examination by scanning electron microscopy. They were chemically fixed with glutaraldehyde, dried nondestructively by the critical point technique, and coated with 15 nm of gold/palladium. The wax of the leaf surface, the stomata, and the fungal uredospores were highly visible. Stages in pustule development from early blistering of epidermal cells to sloughing of uredospores from the mature pustule were observed. Cross sections of leaf through pustules revealed extensive underlying mycelium. Pustules erupted on both surfaces of the leaf, destroying the integrity of the epidermal cells, but the interior leaf cells retained their essential shape and volume.

Other leaves were removed by cutting off the plant tops and plunging them into liquid $N_2$ for a few seconds until the leaves became brittle. The brittle-frozen leaves were stripped from the stems and packed in dry ice. Frozen leaves were ground in cold phosphate buffer, and the extract was centrifuged. The soluble fraction was passed through a gel filtration column, and the protein fraction was lyophilized. Amino acid and protein composition were determined. The soluble protein fraction was studied by a variety of electrophoretic and chromatographic techniques. Slight differences in electrophoretic profiles were noted. A new methodology of high performance multidimensional liquid chromatography is being explored. In the first stage of this approach, complex size exclusion chromatograms were obtained in less than an hour. Apparent moment molecular weights were determined by an online computer and some differences were noted between the various genotypes, both before and after inoculation, particularly after $(NH_4)_2SO_4$ precipitation of isolates.

High performance liquid chromatography seems to have potential as a tool for studying solubilized components of biochemical systems, but the technique is not yet routine, and a number of methodological problems remain to be solved.

## Harvest Induced Senescence in Root Nodules of Alfalfa

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Harvesting (cutting) is thought to produce a number of changes in nodule function and growth in forage legumes. In perennial forage legumes nitrogen fixation is reported to decline sharply after harvest, accompanied by nodule shedding and formation of new nodules as new shoot growth occurs (1,2,3). However, the mechanisms controlling nodule function and growth are not understood for any species. The objectives of this study were to establish the patterns of nitrogen fixation, nodule activity and nodule development associated with forage harvest and subsequent recovery during a cycle of vegetative regrowth in seedling year alfalfa.

Compared with controls, harvesting caused an 88% decline in $N_2(C_2H_2)$ reduction capacity of detached root systems within 24 hr. $N_2(C_2H_2)$ reduction in roots of harvested plants remained low for 13 days and then increased to a level comparable to the controls by day 18.

Protease activity and concentrations of soluble proteins and leghemoglobin in nodules from harvested plants were compared to those in nodules from control plants. Protease activity increased in nodules from harvested plants reaching a maximum at day 7 after harvest after which it declines to a level almost equal to the control by 22 days. In contrast, soluble protein and leghemoglobin concentrations decreased in nodules from harvested plants in an inverse relationship to protease activity.

Nitrate reductase activity in nodules from harvested plants increased significantly within 24 hr after harvest and was inversely associated with acetylene reduction as compared to nodules from control plants. The difference in nitrate reductase activity between nodules from harvested plants and control plants became less evident as shoot regrowth occurred and as acetylene reduction increased in the harvested plants.

No massive loss of nodules occurred after harvest. However, a rapid temporary senescence occurred in nodules of harvested plants. Histological examination of nodules from harvested plants showed that they degenerate at the proximal end after harvest. Starch in the nodule was depleted by 10 days after harvest. The meristem and vascular bundles of nodules from harvested plants remained intact. The senescent nodules begin to regrow and fix nitrogen after new shoots begin to grow.

These studies show that root nodules from alfalfa have an adaptive mechanism for continued growth and development after forage harvest and that they may also have an alternative mechanism for supplying nitrogen to the plant when nitrogen fixation is impaired after harvest.

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# High Levels of Potassium are Needed to Maintain High Alfalfa Herbage Yields

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Alfalfa (Medicago sativa L.) is a heavy feeder on soil K, and adquate amounts must be available to maintain high productivity year after year. Three first-flower cuttings annually before early September are now practiced generally in the North Lake States to obtain high yields of quality herbage. These higher yields with new varieties and frequent harvest schedules emphasize the need to reevaluate the amounts of K needed to maintain high yields. In a recent Wisconsin study (Agron. J., 67:60, 1975), Ranger alfalfa established on low K silt loam soil (127 lbs/A exchangeable K in top 6-inches) was topdressed each year, during the first two of three harvest years, with from zero to 1,000 lbs/A of K as KCl. The soil supplied annually 57 lbs/A of K. Highest average hay yield for 3-harvest years was obtained at the 600 lbs/a K rate (1,200 lbs/A total), and the average herbage K percentage at this rate was 2.8%. Wisconsin recommendations now call for an herbage tissue test of K of near 3.00% at first flower and a soil test for exchangeable K of no less than 350 to 400 lbs/A at the end of the crop season where high yields of quality herbage are expected (Wisconsin Agric. Exp. Sta. Bull. R1741, 1977).

In a subsequent study on low K silt loam soil, Vernal alfalfa yields were increased with both KCl and $K_2SO_4$ fertilization (Agron. J. 68:573, 1976), but a 800 lbs/A of K or higher, yields decreased with the use of KCl. In contrast, high yields were maintained at high rates of $K_2SO_4$. As the rate of KCl topdressed increased in both of the above trials, Cl concentration of the herbage increased (Agron. J. 68:573, 1976; Commun. Soil Sci. and Plant Analysis 6(5):521, 1975 and 8(6):489, 1977). Since herbage yields decreased at KCl rates above 600 lbs/A of K, plant damage presumably occurred because of toxic levels of Cl in the tissues.

Potassium chloride (KCl) is the main carrier of K used throughout the world. As higher fertilization rates of KCl are recommended on alfalfa, there is a need to know more about the toxic levels of Cl and the toxic effects of Cl in herbage tissue. The concentration of Cl that will begin to cause damage to alfalfa herbage tissue has not been determined. Chlorine damaged shoots show leaflets that are yellowed, thickened, and deformed with the internal structures badly disrupted (Can. J. Plant Sci. 57:293, 1977). However, many shoots may be killed by Cl before they elongate very far, so that Cl concentration of the herbage at bud or first flower may not provide an indication of toxic concentration. As high as 12 to 14% Cl (dry wt.) has been obtained in unelongated shoots at point of death (unpublished data). With the application of 600 lbs/A of K, or more, as KCl, alfalfa may be injured by the Cl absorbed by the plants. It may be necessary to split large applications and allow several months between applications, depending on rainfall pattern. An alternative is to use $K_2SO_4$, or to apply part of the K as $K_2SO_4$.

Potassium appears to be absorbed mostly by alfalfa roots near the surface of the soil. This was observed in a study (Agron. J. 65:769, 1973) where 200

lbs/A of $K_2SO_4$ was placed at different soil depths below a 2-year-old stand of Ranger alfalfa growing on a low-K silt loam soil. Three harvests at first flower showed that the alfalfa recovered 41, 29, 19, 16, 10, 15, and 11% of the added K from the surface, 3, 9, 15, 21, 27, and 33-inch soil depths, respectively. These data indicate that mixing K into the soil surface is not necessary and that maximum efficiency can be obtained from topdressing. Since elements are absorbed mostly from the soil surface and topdressed K and P remain largely at the soil surface, alfalfa varieties that have heavy surface rooting are the most efficient in obtaining topdressed fertilizers.

## Utilization of Deproteinized Juice Extracted from Alfalfa Herbage

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The system of plant juice protein-forage production has as an end product a large volume of residual juice, which must be disposed of in some manner, to avoid serious environmental pollution. This end product has been termed deproteinized plant juice (DPJ). It constitutes about 50% of the weight of the harvested green plant before pressing with most crops. DPJ generally contains from 4 to 5% solids and generally is very high in concentration of postassium ($\pm$0.45%) and nitrogen ($\pm$0.12%). Several methods of disposing of DPJ have been under investigation. These include: (1) use as a fertilizer, (2) for production of protein from single cell organisms, and (3) recycling to the fresh forage or added to the pressed forage.

Studies were conducted to determine the effects of utilizing DPJ as a fertilizer on alfalfa, *Medicago sativa* L.; bromegrass, *Bromus inermus* Leyss.; and corn, *Zea mays* L. (Agron. J. 69:685, 1977). In field experiments, deproteinized alfalfa juice (DAJ) was applied to: (1) an alfalfa-bromegrass mixture, (2) to bromegrass, and (3) to corn; at depths of zero, 0.625, 1.25, and 2.50 cm. Increased yields of all three crops were obtained with the annual application of 1.25 cm of DAJ. However, plant damage and yield reductions occurred to alfalfa and corn when DAJ was applied at rates of 2.5 cm, with only minor damage to bromegrass. Per hectare yields of crude protein were increased and concentration of K in the herbage of alfalfa, bromegrass, and corn was higher where DAJ was applied. Available P and exchangeable K in the soil generally increased with each increment of DAJ applied, and soil pH was maintained at satisfactory levels as a result of Ca and Mg additions from DAJ.

When oats followed corn in the rotation, with no further fertilization with DAJ, the residual yields of grain were higher wherever DAJ previously had been applied.

Greenhouse studies with alfalfa were conducted to observe more closely the possible causes of plant damage when DAJ is applied as a fertilizer. In one series of experiments (Agron. J. 69:690, 1977), DAJ was applied to alfalfa at depths of from 0.16 to 10.0 cm. Plants fertilized with DAJ at depths of

1.25 cm or more showed chlorotic symptoms and growth retardation. Only a few plants survived at the 5.0, 7.5, and 10.0 cm rates. When DAJ was applied on timothy plants, results were similar to those when alfalfa was fertilized with DAJ, but timothy plants appeared to survive better than alfalfa under the higher rates of DAJ. Yields of the test plants decreased when more than 1.25 cm of DAJ was applied.

There was some speculation that saponin, a glycocide that occurs in alfalfa and other plants, caused the damage when DAJ was applied to alfalfa, bromegrass, timothy, or corn. In another series of greenhouse experiments (Agron. J., In Press), DAJ extracted from low and high saponin alfalfa strains was applied back to alfalfa growing in pots of soil. Yields were not significantly different whether DAJ from low or from high saponin alfalfa was applied. It was concluded that saponin was not the causal agent in the injury or death of alfalfa or other plants when fertilized with DAJ.

In another greenhouse experiment, results were similar where deproteinized juice extracted from oats (DOJ) was compared with DAJ when applied to alfalfa. Yields declined and damage occurred when either DOJ or DAJ were applied to alfalfa at depths greater than 1.25 cm. Yield decline and injury to alfalfa were not as great when DOJ was applied at 2.5 cm as with DAJ, but practically all plants were killed with either DOJ or DAJ at 3.75 cm.

It is hypothesized from these experiments that a possible cause of injury and/or death to plants from applications at high rates of DPJ could be toxic levels of chlorine (Cl). As DPJ rates increased, Cl concentration increased in the test plants. Another cause of injury could be a lack of soil oxygen for the plant roots. Saturation of the soil with high rates of liquid, together with excessive fungi growth on the soil surface which use oxygen, may result in a low oxygen supply for normal functioning of roots. Low soil oxygen increases the availability of soil Mn, but toxic Mn concentrations in the test plant herbage were not observed. Another possible cause of the plant damage could be phytotoxic compounds in the DPJ, or soluble and/or volatile microflora breakdown products of the DPJ.

## Crownwart of Alfalfa in Pennsylvania

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Crownwart is a disease of alfalfa caused by the chytrid fungus, Physoderma alfalfae (Lagh.) Karling. The fungus invades crown buds and induces hypertrophy of the developing shoot tissues. Crownwart occurs most commonly on alfalfa grown under irrigation in our western states and also in Europe, Australia and New Zealand. It has not been reported to occur in the northeastern United States although it was found in Alabama.

Alfalfa plants were dug from fields in Westmoreland County in southwestern Pennsylvania on a triweekly basis from 30 March to 5 October 1977, as part of a root disease survey. Crownwart was observed first on plants dug from one field on 11 May. Diseased plants from the same field were found on 1 June, 22 June, and 13 July. Throughout June, galls were firm and white; by 13 July galls were turning brown and deteriorating. Only one intact gall was found on roots dug on 3 August.

In June, crownwart was found on alfalfa on two other farms within 5 miles of the original disease site. All fields in which crownwart occurred were low-lying and poorly drained.

In the original field, disease incidence ranged from 10 to 40% of the plants sampled on each date. Galls numbered from 1 to 8 per plant and measured from 3 to 22 mm across the longest dimension. Because this pathogen cannot be cultured, diagnosis was based upon the characteristics of the galls and on the presence, within the galls, of chlamydospores that matched for color, appearance and size those described by earlier workers.

The finding of crownwart in Pennsylvania represents a significant extension of its geographic range. The disease is not considered to be serious, and no effect of the disease on yield or stand was evident during the 1977 growing season. Because of the high incidence of diseased plants at three locations, it is likely that crownwart has occurred other years in this area.

## *Phoma* Leafspot and Alfalfa Quality

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The effects of foliar disease caused by *Phoma medicaginis* on alfalfa quality were investigated with greenhouse-grown, moderately diseased (about 25% of leaf surface) Saranac alfalfa. Diseased and healthy leaf samples were compared for six quality constituents, *in vitro* dry matter digestibility (IVDMD), palatability to adult meadow voles, and the performance of weanling voles fed the alfalfa at 60% of their diets.

The quality constituents of diseased leaves differed from those of the healthy leaves as follows: acid detergent fiber up 55%, cellulose up 34%, cell

walls up 32%, lignin up 300%, protein down 31%, total nonstructural carbohydrate down 44%. The IVDMD of diseased samples was 75% compared to 83% for healthy alfalfa leaves.

Palatability to adult voles was assayed in 0.5-hr feeding trials with the voles having a choice between the test sample and their usual mouse chow. The voles ate 0.25 g of diseased leaves, which was less (P 0.05%) than the 0.35 g of healthy leaves eaten. Weanling meadow voles were fed the following diet formulation: alfalfa leaves 60%, carbohydrate 35%, vitamins 1%, minerals 3%, and oil 1%. The voles ate significantly more of the diseased alfalfa diet than they did of the diet containing healthy leaves, but weight gains were the same for voles on either diet. The digestible dry matter of the diseased alfalfa diet was 12% lower than that of the healthy alfalfa diet.

Alfalfa leaves moderately diseased with *Phoma* leafspot were lower in quality, were less palatable to adult meadow voles, and were less nourishing to weanling voles than were comparable healthy leaves.

## The Performance Under Intensive Continuous Grazing of Second Generation Bulk Populations Derived from Crosses Between Wild and Exotic Alfalfas and Cultivared Nonhardy Varieties

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Most of the alfalfa in Australia is grown in environments classified as Mediterranean or Mild Warm Temperate. To maximize yield in these environments, alfalfa cultivars of the nonhardy type are used. However, a large proportion of the Australian alfalfa acreage is used for extensive grazing by sheep and cattle and not for hay and fodder production. In grazing systems, the nonhardy types are extremely sensitive to long spells of hard grazing and the lack of recovery time between grazings. Experience with exotic cultivars and wild growing populations from the Middle East, Asia, and North Africa had shown that many of these populations persisted better than nonhardy Australian cultivars when grazed but had lower yields.

Hybrids were produced between fifty alfalfa populations differing morphologically from nonhardy erect growing varieties, which were used as the alternate parent group. The 1st generation was space planted in 50 blocks of 150 plants and seed produced by open pollination, thereby allowing intercrossing of the hybrids within and between blocks. The blocks were harvested separately and the progeny sown at 10 kgm $ha^{-1}$. After allowing 12 weeks for establishment, the plots were continuously graced by sheep, keeping the height of growth below 5 cms using a put-and-take system of stocking management. Apart from two interruptions totalling 60 days for yield assessments the plots were grazed for 22 months. The experiment was conducted at the Northfield Laboratories, near Adelaide, South Australia. During summer

irrigation was used to sustain active growth. The average stocking rate throughout the experiment was 10.9 sheep per acre.

Plant density and plot yields were measured 190 days after sowing (100 days after grazing commenced). There were no significant differences between the bulk populations and commercial check varieties. However, after 800 days very significant differences in plant density and plot yields occurred (Table 1). The yields at 800 days were taken 41 days after grazing was terminated. The most outstanding single population was derived from wild Iraqui material (63 plants $m^{-2}$ and 288 gm $m^{-2}$); other outstanding parents were wild Spanish and cultivated Afghan lines. Notable was the performance of 'Hunter River' which persisted moderately well; a result which may be indicative of the preference for this variety by Australian farmers before the occurrence of SAA and BAA. The other check varieties suffered severe decline. Persistance was not markedly related to any particular morphological characteristic, but bulks which produced shoots prolifically and nonsynchronously and tended to procumbency were the most successful. 173 accessions were used in the parentage and the total population of bulks is extremely heterogeneous.

Presently a SAA resistant synthetic is being selected from persistent material and the most persistent lines are being multiplied as germplasm sources.

Table 1

| Parent Population Groups* (crossed to nonhardy cultivars) | Plant Density (plants $m^{-2}$) day 190 | Plant Density (plants $m^{-2}$) day 800 | Yield (gm $m^{-2}$) day 190 | Yield (gm $m^{-2}$) day 800 |
|---|---|---|---|---|
| | (days from sowing) | | | |
| 1. Canada, U.S.A. (rhizomatous and creeping) | 116 | 19 | 121 | 175 |
| 2. Argentine (creeping) | 135 | 33 | 129 | 217 |
| 3. Algeria (wild-growing) | 120 | 49 | 97 | 207 |
| 4. Spanish (wild-growing) | 107 | 41 | 130 | 259 |
| 5. French (*M. falcata*) | 53 | 18 | 78 | 197 |
| 6. French (*M. sativa*) | 111 | 18 | 128 | 168 |
| 7. English (creeping) | 100 | 10 | 150 | 118 |
| 8. Iraq, Iran, Afghanistan | 130 | 39 | 133 | 271 |
| 9. USSR (*M. falcata*) | 114 | 31 | 101 | 152 |
| 10. USSR (*M. coerulea*) | 110 | 18 | 122 | 255 |
| 11. USSR (*M. polyehroa*) | 113 | 33 | 109 | 290 |
| 12. USSR (*M. hemicycla*) | 102 | 34 | 140 | 227 |
| 13. USSR (*M. glutinosa*) | 110 | 26 | 113 | 238 |
| 14. USSR (*M. sativa*) | 119 | 21 | 120 | 187 |
| 15. New Zealand "Glutinosa" | 105 | 10 | 138 | 175 |
| 16. Australian creeping rooted | 120 | 12 | 138 | 162 |
| 17. Turkish (wild-growing) | 98 | 2 | 132 | 20 |
| Check Varieties | | | | |
| Hunter River | 125 | 28 | 140 | 253 |
| Paravivo (ex African) | 122 | 1 | 118 | 54 |
| Hairy Peruvian | 115 | 5 | 128 | 86 |
| Du Puits | 130 | 6 | 142 | 111 |
| LSD's .05 | --- | 25 | --- | 117 |
| .01 | --- | 33 | --- | 154 |
| .001 | --- | 43 | --- | 198 |

*The number of populations in a group ranged from 1 to 6.

## Committee on Nutritional Value of Alfalfa

This committee, formed in 1976, is a replacement for the Committee on Potential Research Problems Associated with New Uses of Alfalfa such as protein Extraction. The duties were those of the previous committee, for example,

1. Review work at various institutions on alfalfa protein extraction and utilization as well as other new uses.

2. Study available methods and procedures to see if there are problems that the NAIC should consider.

3. Review Food and Drug Administration Regulations in regard to new cultivars and alfalfa protein.

expanded to include:

4. Examination of the present and potential roles of alfalfa in the nutrition of animals and people.

5. To identify those nutritional situations in which alfalfa may be deficient in meeting dietary needs.

6. Suggestion of experimental procedures which may be used by breeders to improve the nutritional value of alfalfa.

7. Other items which the committee may recognize as pertinent to the general area of nutrition of alfalfa.

8. Report on Committee activities to the NAIC in June, 1978.

I. Leaf Protein Concentrates.

The previous committee reviewed institutional work on protein extraction and utilization to the NAIC in 1976 and the University of Wisconsin has published "Plant Juice Protein and Moisture Expression from Organic Material A Bibliography" Wisconsin Bulletin R2386, May 1976 and an Addenda, Bulletin R2386-1, April 1978. The approval of the use of LPC in human foods by the Food and Drug Administration is the proper responsibility of the process developers, food scientist and the developing industry. The NAIC or some of its members may need to aid in the development of the application for FDA approval.

Leaf proteins concentrate research objectives may be divided into two general areas, namely as a human food additive and as an animal feed protein supplement.

A. LPC as a food additive is a long range program to improve the nutrition of human diets and to substitute for traditional protein when human populations needs exceed the production from traditional sources. A shorter range program is to improve the

protein nutrition in the developing nations and other areas where dietary protein is below minimum.

B. LPC for animal nutrition development is generally to make available a low fiber, high protein constituent for inclusion in nonruminant animal rations. Some people believe that this should be an "on farm" operation where the products could be fed without drying. Such an operation would require both ruminant and nonruminant animals be available to utilize the two main fractions, for example, press residue and green protein concentrate, and utilization or disposal system for the brown liquor. Others believe that it needs to be a commercial operation with drying facilities so that the market is wide spread. A combination of the two is possible however in areas where ruminant animals prevail, in that the press residue may be used locally as is or after ensiling while the green protein concentrate could be transported to a central plant for drying and distribution. Disposal of the brown liquor would still be necessary, but it could possibly be returned to the land. The feed value in the brown liquor has not been adequately determined.

NAIC may best help in the development of an LPC industry by developing alfalfa cultivars particularly suitable for protein extraction, such as:

1. Increasing total protein content.

2. Increasing the soluble or extractable protein.

3. Reduction or elimination of chlorogenic acid or the chlorogenic acid--protein complex. The physiological functions of chlorogenic acid will probably need to be determined before much headway can be made on this problem.

4. Reducing saponin levels.

5. Improving the amino acid profile of the protein.

Industrial development of LPC is largely an economic problem, for example, production, utilization, and FDA approval costs.

II. Other new uses.

Alfalfa contains a great number of factors (chemical entities) both known and unknown, which may have a beneficial use. In the last few years studies have indicated that alfalfa meal has an effect in decreasing elevated plasma cholesterol in primates, that alfalfa may have an influence on the metabolism of chemical carcinogens, and that alfalfa contains a plant growth factor, triacontanol, which may be used to improve crop yields (Stanley Ries, Michigan State University).

NAIC may help in the development of such new uses by interdisciplinary cooperation in determining cultivar variation and increasing cultivar content of the factors involved.

III. Nutritional quality of alfalfa.

The main effort, over the years, by alfalfa breeders has been to increase yield and in recent years to introduce insect and disease resistance or tolerance into high yield cultivars. FDA (GRAS), however, says that new cultivars must, in terms of composition, vary only slightly from cultivars they replace. Breeders can't add resistance or change composition significantly without documenting the metabolic consequences. Relatively little work has been done on developing cultivars having higher nutritional qualities. The following are among those nutritional factors which deserve attention from alfalfa breeders, but will require interdisciplinary cooperation.

1. Protein--a primary virtue of alfalfa.

   a. Content--A genetic variation has been found in clones of up to 9 percent, but not among varieties. Location was shown to have a significant effect. The protein content-stage of physiological maturity has a very high correlation, thus in genetic studies of protein variation it is extremely important that physiological maturity at sampling be well controlled. Increased protein content would be valuable to utilization in animals, particularly non-ruminants, but there is considerable doubt that these values might revert to the producers, except that of greater market potential.

   b. Solubility--Protein solubility apparently can be genetically influenced and may play an important role in animal nutrition, as well as in LPC extraction. There is an indication that a low solubility protein is desirable for ruminant animals. It is probable that some monogastric animals would benefit from a high protein solubility.

   c. Protein quality--amino acid profile. Alfalfa has a fairly good amino acid profile except for methionine and there has been no evidence of genetic variation. It has been speculated that utilization of cell culture techniques may be the only possibility of introducing increased methionine content into alfalfa protein. Some research has shown that other marginally difficient amino acids--threonine, isoleucine, phenylalanine, leucine and tyrosine--may respond to genetic selection.

2. Digestible energy.

   The need or desirability of increasing digestible energy in alfalfa is controversial. Some people argue that the energy value is not important since it is readily and economically

obtained from cereal grains. Others claim that the use of alfalfa in high energy animal rations, at least for monogastrics, is limited by its energy value simply because there is not room in the ration for low energy materials. Although alfalfa has a lower digestibility than some grasses, it has a very high voluntary intake and rate of passage so that the digestible energy intake of alfalfa by ruminants is equal to or better than grasses. It is possible that increased energy could be provided through chemical treatment such as that proposed for straw, sawdust and other fibrous materials (conflicting results of such treatment have been reported) but may not be feasible economically or in respect to other nutritional factors. The use of cellulolytic enzymes is also a possibility.

3. Anti nutritional factors and nutrient availability.

Some anti nutritional factors such as saponins, protease and vitamin inhibitors, the bloat-factor, and lectins effect nutritional quality. Other chemical entities, such as chlorogenic acid, may also have an effect. The big question is can these factors be eliminated or reduced without a deleterious effect on plant growth, insect and disease resistance, etc. Some work is going on concerning these and other such factors. Reduced saponin content in alfalfa and alfalfa protein concentrates gave increased weight gains with chicks, rats and swine. The higher palatability of lower saponin materials was at least partially responsible for increased growth rate due to greater intake. We know that some processing methods affect the inherent nutritive qualities of alfalfa such as heat denaturation of protein, but do not know how inherent cultivar differences might be affected by the processes.

4. Mineral composition.

Minerals are supplied as part of the ration but one study in the southwest in which alfalfa having Ca:P ratio variations of 5.4:1 to about 12:1 showed that these influenced the results of feeding trials with dairy heifers. The ratios could be related to soil pH, type of irrigation water or soil phosphorous fixation. Variety had no effect on mineral composition, but locations did except for iron.

5. Leaf shattering.

Dry matter loss, mostly leaves, during hay making operation may be quite high (20-28%) thus reducing some of the virtues for which alfalfa is known. If this loss could be reduced through equipment design, process management or genetics the value of alfalfa hay would be significantly increased.

IV. Tools for measuring quality.

A great many tools are available for measuring quality other than the ultimate animal. These tools may be simple--kjeldahl nitrogen, or complicated--amino-acid analyzer, and require varying degrees of specialized training and understanding. Chemists, biochemists, engineers, etc. could be very helpful not only in analytical determinations but also in planning a research program to obtain meaningful results. These specialists should be an integral part of your program. However, it is economically important not to over analyze; have a reason for each analysis.

The development and availability of commercial infra-red reflectance instruments presents the possibility of low-cost analysis for protein, neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin and dry matter digestibility. At the present time only protein and possibly neutral detergent fiber appear to have adequate reproducibility for use in a breeding program. Infrared reflectance instrumentation for these purposes is still not a "turn key" operation. Careful attention must be given to calibration of the instrument and to ensure that standard errors of prediction are acceptable to the objective. Relatively recent developments in protein analyses which allow rapid economical screening of large numbers of samples include block digestion, steam distillution and nitrogen release determined by semi automatic titration (Tecator, Inc.) or directly by specific ion electrodes (Technicon Instruments Corp. and Beckman Instruments Inc.). Other ionic entities may also be determined by specific ion electrodes on the digestion mixture. The improved Udy dye binding procedure and equipment (Tecator) may also be a valuable low cost screening procedure.

Determination of the amino acid profile (protein quality) has been made much easier with the development of amino-acid analyzers (available from several manufacturers), and the time and cost may be reduced if only specific amino acids, such as lysine and methionine, are determined.

The Tilly-Terry *in vitro* digestibility is still the best method for screening large numbers of samples for digestibility. Modifications, which may aid in screening comparisons, utilizing cellulase enzymes are under development.

A semi automatic system has been developed for acid detergent fibre, crude fibre, hemicellose, lignin and similar procedures has been developed. (Tecator Fiber Tec system).

Animal performance is still the ultimate analytical procedure.

V. Other concerns in cultivar development.

A. Cell culture techniques in plant breeding. There is currently much interest in cell culture for interspecific hydridization and for screening a large number of genotypes. Although cell culture

techniques will undoubtedly contribute to alfalfa breeding there is, as yet, no established procedure by which cell culture can contribute to practical improvement in nutritive value. However, basic research in cell culture techniques with a view to use in alfalfa breeding should be encouraged.

B. Improve the vitality of root system and develop cultivars with increased resistance to insect and disease damage including the crown. Forage response may not be an adequate indicator of root vitality, thus it probably will be necessary to develop new techniques of plant proliferation to allow cultivar development in spite of root destruction.

C. Transpiration rate--It would be ideal, of course, if the water transpiration rate during growth were to be minimal for physiologic development, but when cut the rate would increase to a maximum for wilting or drying. In recent years some chemicals, fusicoccin and the morphactins, have been found which influence stomatal opening and transpiration. The biochemical mechanisms of stomatal opening or closing is being studied. Whether these mechanisms can be controlled by genetic variation or not is unknown. If transpiration could be reduced genetically, drought resistant and reduced water requirement cultivars might be developed. Since the ideal is not probable, it may be necessary to trigger stomatal opening when cutting to increase the drying rate.

D. Yield potential. Alfalfa yield, a primary goal of most breeders, is mainly controlled by management practices, environmental conditions and insect and disease resistant or tolerant varieties. An understanding of the limiting mechanisms of plant development might lead to increased yield potential. Reducing the transpiration of alfalfa could also result in increased yield potential.

VI. Thoughts on studies by committee.

At first the assignment to this committee appeared exciting, perhaps through brainstorming we could make significant recommendations on direction and methods of research. However, brainstorming via correspondence severely limits interaction. We also tend to procrastinate, at least the chairman does, on these committee assignments because of the "Importance" of our own programs and other responsibilities at our home base. One committee member wrote "There is so very little support of research in nutritional quality of alfalfa, and most other crops, that there isn't much of a base for making decisions". It may be necessary from time to time for NAIC to assign a committee a broad responsibility, such as this one, but generally it would be perferable because of time and distance to have a narrower or more definitive assignment.

VII. Recommendations.

We have no specific program recommendations except as each of you

react to the ideas and concerns in the report. Terminology for "tannins," "polyphenols," and so forth, seems to be confusing. NAIC might bring this to the attention of the Crop Science Society of America with a recommendation that a standard form of usage be adopted in reference to the influence of phenolic constituents on the nutritive value of feedstuffs. Since alfalfa is the preferred crop for LPC production, members of NAIC should keep abreast of development of LPC. We would urge you to seek inter-disciplinary cooperation, particularly in your locality, so that your research may be broadened and more effective.

Submitted by,

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## Committee on Standard Tests for Characterizing Disease and Insect Resistance of Alfalfa Cultivars

As recommended by the 25th Alfalfa Improvement Conference, this committee has reviewed the standard tests bulletin (ARS-NC-19) for changes in scientific names of pests, names of research personnel, check cultivars, evaluation procedures, and pest distribution maps with the objective of publishing a revised bulletin. Recommendations for many changes and additions to the bulletin have resulted from that review. Presently, some new or revised descriptions have been written, new maps are being drawn, and other appropriate materials are being assembled in anticipation of publishing a revised bulletin in early 1979.

The collection of standard seed lots of the 17 check cultivars recommended in the standard tests bulletin has been completed. In most cases, foundation seed was obtained; however, registered or certified seed has been substituted where necessary. These seed lots will serve as a uniform source for the check cultivars and will be supplied in amounts not exceeding 20 g to those conducting evaluations in which the standard checks are needed.

Requests for seed of the standard checks should be addressed to J. H. Elgin, Jr., USDA-SEA, Field Crops Laboratory, Bldg. 001, BARC-West, Beltsville, MD 20705.

Respectfully submitted by:

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## Report of the Committee on Available Breeding Lines of Alfalfa

The committee contacted all Agricultural Experiment Stations in the United States and Canada and representatives of the seed industry for additions to the list of available breeding lines included in previous reports. The new entries are as follows:

| State/Province | Contact | Official Release | Stock | Description |
|---|---|---|---|---|
| Colorado<br>USDA/SEA/AR | C. E. Townsend | C-6 | Seed | C-6 Traces to a collection of "drought resistant" selections made by A. C. Dillman at Belle Fourche, S. D., from 1910-14 and to a collection assembled by G. A. Rogler at Mandan, N.D. Both collections trace directly to N. E. Hansen's 1900 introductions. |
| Kansas<br>USDA/SEA/AR | E. L. Sorensen | KS 76 | Seed | Derived from 'Kanza' by utilizing 4 cycles of successive elimination type selection in seedling stage for resistance to bacterial leafspot, pea aphid, and spotted alfalfa aphid; 3 cycles of selection for downy mildew; and 1 cycle for Leptosphaerulina leafspot. |
| Kansas<br>USDA/SEA/AR | E. L. Sorensen | KS 77 | Seed | Derived from 'Arc' by recurrent phenotypic selection on seedling stage. One cycle of successive elimination under controlled conditions was practiced for resistance to Phytophthora root rot, 2 cycles for downy mildew, and 3 cycles for pea aphid and spotted alfalfa aphid. |
| Nevada<br>Minnesota<br>USDA/SEA/AR | O. J. Hunt | NMP-8 | Seed | Derived from anthracnose resistant selections from Moapa 69 and Arizona Ron PX followed by 2 cycles of phenotypic recurrent selection for both anthracnose and Phytophthora root rot resistance in the recombined population. Highly resistant to Fusarium root rot. |
| Nevada<br>Minnesota<br>USDA/SEA/AR | O. J. Hunt | NMP-10 | Seed | Developed from a population of 160 plants selected anthracnose resistance from SW17 (10), SW29 (58), CA EXP. 47 (31), N14120P (10), and El Unico (44) followed by 2 cycles of selection for both anthracnose and Phytophthora root rot resistance in the recombined population. |
| Nevada<br>USDA/SEA/AR | O. J. Hunt | NMP-9 | Seed | Developed from Northern root knot nematode resistant selections from the hardy cultivars. Resistant to root knot nematode and bacterial wilt. |
| Nevada<br>Washington<br>Oregon<br>Utah<br>USDA/SEA/AR | O. J. Hunt | Nevada Syn YY | Seed | Developed by backcross breeding with Northern root knot nematode resistant 'Vernal' clones as donor parents and elite African clones as recurrent parents. Resistant to *Meloidogyne hapla* and *M. incognita*. |
| Nevada<br>Minnesota<br>USDA/SEA/AR | O. J. Hunt | $MSE_6SN_3W_3$<br>$MSF_6SN_3W_3$ | Seed | Developed by phenotypic recurrent selection for resistance to stem nematode and bacterial wilt in $MSE_6$ and $MSF_6$. The original populations were described when first released as resistant to pea aphid and spotted alfalfa aphid. (Crop Sci. 10:73-75, 1970) |
| Nevada<br>Washington<br>USDA/SEA/AR | O. J. Hunt | Washington SNI | Seed | Washington SNI was developed from diverse germplasm and selected for resistance to stem nematode. Resistant to stem nematode and bacterial wilt. |
| North Carolina<br>Nevada<br>USDA/SEA/AR | Will A. Cope | NCCr1 | Seed | Bred from 'Canadian Creeper; and North Carolina breeding stocks by recurrent field selection for the creeping-rooted character and adaptation to North Carolina. |

| State/Province | Contact | Official Release | Stock | Description |
|---|---|---|---|---|
| North Carolina<br>Nevada<br>USDA/SEA/AR | Will A. Cope | NCW 21 | Seed | Bred by recurrent field selection for vigor and tolerance to defoliation by alfalfa weevil larvae. Laboratory selection for anthracnose resistance took place in the last generation. Resistant to anthracnose, pea aphid, and has high tolerance to alfalfa weevil larvae feeding. |
| USDA/SEA/ R<br>Washington | J. H. Elgin, Jr. | WDS3P1 | Seed | Developed from the cultivar Vernal. Highly resistant to stem nematode, Phytophthora root rot, and bacterial wilt. (Crop Sci. 18:530, 1978) |
| | | WIS1P1 | | Developed from a hand-pollinated intercross of 43 plants from Apalachee and 30 plants from Saranac. Highly resistant to stem nematode; moderately resistant to Phytophthora root rot; and slightly resistant to bacterial wilt. (Crop Sci. 18:530, 1978) |
| USDA/SEA/AR<br>Washington | R. N. Peaden | WAS3 | Seed | Traces to Team. |
| | | WCS3 | | Traces to Nev. Syn Y (which traces to bacterial wilt resistant selections from PI 211608). |
| | | WDS3 | | Traces to Vernal. |
| | | WFS3 | | Traces to Williamsburg. |
| | | WGS3 | | Traces to Talent. |
| | | WHS3 | | Traces to PI 141462. |
| | | WIS3 | | Traces to Lahontan. |
| | | WJS1 | | Traces to Saranac. |
| | | WLS1 | | Traces to Scano. |
| | | WMS1 | | Traces to Aragon. |
| | | WRS1 | | Traces to Nematol I. |
| | | WUS1 | | Developed from an intercross of 33 plants tracing to Nemastan, DuPuits, Lahontan, Resistador, Vernal, Caliverde 65, Ranger, and Moapa. |
| | | WXS1 | | Developed from an intercross of 10 Nevada clones. |
| | | WYS1 | | Developed from an intercross of 91 plants, tracing to Washoe, Apalachee, Williamsburg, DuPuits, Cherokee, Vernal, Team, Dawson, and to experimental Nevada lines. |
| | | WZS1 | | Developed from an intercross of 39 plants tracing to Nev. Syn WW, Williamsburg, Talent, DuPuits, PI 141462, Nev. Syn EE, Nematol, Apalachee, and Lahontan. |
| | | W1S1 | | Developed from an intercross of 73 plants tracing to Apalachee and Saranac. |
| | | W2S2 | | Traces to Arc. |
| | | W8S0 | | Traces to WAS3, WCS3, WDS3, WES3 (developed from root-knot nematode resistant Nev. Syn WW), WFS3, WGS3, WHS3, and WIS3. |
| | | | | All 18 populations are highly resistant to stem nematode. (Crop Sci. 18:529, 1978) |

This report does not include official cultivar releases and plant introductions because those are published elsewhere. Thirty-two breeding lines were officially released during the 2-year period since the last report of this committee.

More than 1,000 individual packets of seed of these officially released breeding lines were distributed upon request by releasing stations. The total would be considerably higher because answers were not received from several scientists who made recent releases.

The committee report at the 25th Conference in 1976 recommended consolidating into one publication all information on breeding lines which have been officially released to date. This consolidation has been completed, the publication has been edited and is ready for the printer. It will be published as a USDA/SEA Series and will contain a complete description of each line and an index of breeding lines by states/province, type of stock, and major characteristics of the line.

The committee recommends continuation of the function of the Committee on Available Breeding Lines of Alfalfa.

Respectfully submitted by:

Ike I. Kawaguchi
E. S. Horner
M. H. Schonhorst
Bill Melton
O. J. Hunt, Chairman

## Committee on Alfalfa for Dryland Grazing

Objectives of this committee were threefold: 1) to review the literature concerning the persistance of alfalfa under dryland grazing, 2) To develop and state, insofar as possible, concepts of the salient physiological characteristics contributing toward stand longevity under range conditions, and 3) To suggest germplasm sources, techniques and breeding procedures contributing toward stand longevity under range conditions. Committee members and several other interested scientists met several times to discuss the topic of alfalfa use in range environments. We decided to divide the topic into five subject matter areas and to prepare a paper describing the available information in each area. It is intended that the five papers will be compiled into one general publication. We believe that this publication would be of use for scientists involved in either teaching or research. A summary of each of the five papers are reported below:

A. Grazing Management Systems - R. J. Lorenz, Research Agronomist, Madan, ND
Dr. Lorenze discussed the three management systems in use in the Northern Great Plains: 1) Continuous grazing, 2) Early grazing of cool-season grasses for 30-45 days, and 3) Grazing, commencing later in the season on warm-season grasses. He reviewed long-term grazing of alfalfa-grass mixture at Mandan, ND; South Dakota; Miles City, Montana; Swift Current,

Saskatchewan; and Dickinson, ND. He commented on suitability of the more common alfalfas to fit into these three systems of grazing. His report is being reviewed.

B. Environmental Factors and Alfalfa Resistance in Dryland Pastures and Rangeland - R. E. Ries, Range Scientist, Madan, N.D. Dr. Ries reviewed the literature under two headings: 'Environmental Factors and Dryland Pasture and Rangeland' and 'Promising Alfalfas for Dryland Pastures and Rangeland Alfalfa'. The literature under environmental factors included climatic, edaphic, and biotic factors and discussed the interaction of these three groups of factors on the persistance and growth of alfalfa in rangeland. The discussion of promising alfalfas included characteristics that he as a rangeman and ecologist would wish to see in a rangeland alfalfa. He listed some of the investigative areas that should be pursued to best understand the role of alfalfa and legumes generally in the rangeland environment. He stressed the importance of persistance in a rangeland alfalfa. The review is quite complete, stressing some 33 references.

C. Diseases, Insects, and Other Pests of Rangeland Alfalfa - C. E. Townsend, Plant Breeder, Fort Collins, Colo. Dr. Townsend approached this review from an alfalfa breeders' point of view. With the help of various experts, he has attempted to assess the need for breeding work in developing resistance to range pests. Among the troublesome insects, he mentions aphids, weevils, and grasshoppers. The grasshoppers are particularly devastating in early growth stages of alfalfa. To date, there appears to be little or no breeding of alfalfa for grasshopper tolerance or resistance. Grasshoppers in rangeland are controlled by spraying. He found, in his review, that pocket gophers were a serious problem to most legumes, including alfalfa, in rangeland. Diseases of rangeland alfalfas do not appear very devastating in the drier regions.

D. Selection for Drought Resistance in Alfalfa - C. S. Cooper, John Carlson, and R. L. Ditterline, Agronomists, Bozeman, Mt. This is an excellent review of the literature on drought resistance generally and drought resistance of alfalfa in particular. It includes 63 references. Under the heading, Influence of Drought on Plant Growth, topics such as: physiological processes within the plant affected by water deficits, limitation of germination as affected by acidity, retardation and stunting of growth as a result of water stress, metabolic and mechanical injury from tissue dehydration and overheating associated with drought and stomatal closure were reviewed. The measurements of drought resistance considering both morphological and anatomical factors were also reviewed. Under Selection Criteria, they reviewed germination against stress, leaf water potential vapor equilibrium, liquid exchange, vapor pressure, beta gauge, osmotic potential, elongated closure and diffusion resistance and desiccation tolerance. They also reviewed the literature on ethylene determination and proline accumulation, and chlorophyll stability index. The paper ends with a section on determining criteria for selecting drought resistance alfalfas.

E. Alfalfas for Dryland Grazing - M. D. Rumbaugh, Plant Breeder, Logan, Utah. Dr. Rumbaugh summarized the literature on the available alfalfa germplasm.

He reviewed the early introductions of Medicago falcata, listing their places of origin and illustrated how they were instrumental in developing the current range-type alfalfas. In general, his report illustrates the paucity of range-type alfalfas and the extremely narrow gene base from which several of them developed; at least narrow in terms of the creeping rooted characteristic. His report cites some 34 papers and provides a good report of the status of germplasm as it is today. He divides his report into root-proliferating alfalfas under which he describes the early falcata, Rambler, Travois, Roamer, Drylander, Kane, Roverde, Spredor, Cancreep, Victoria, and the rhizomatous alfalfas including Sevelra, Nomad, A 169, A 224, Teton, and College Glutinosa.

Besides the literature searches and paper preparation, members of the committee have initiated two cooperative investigations. 1) Dr. Rumbaugh, Townsend and Wilton are investigating adaptation of alfalfas on a regional basis. 2) Ries and Wilton are investigating micro-environment of some range-type alfalfas in their natural habitat.

Respectfully submitted by:

| | |
|---|---|
| C. S. Cooper | M. D. Rumbaugh |
| R. J. Lorenz | C. E. Townsend |
| R. E. Ries | A. C. Wilton, Chairman |

## Committee on Variety Certification

The charge given to the committee by the 25th Alfalfa Improvement Conference was to monitor genetic integrity as affected by the many factors involved in certifying alfalfa seed fields, and to examine the isolation of certified fields and the effect of this isolation on genetic integrity.

### Monitoring Genetic Integrity

The seven possible problem areas for contamination, as outlined in the committee's report to the 25th Alfalfa Improvement Conference, were considered. These points include: 1) age of stand for seed production; 2) field size; 3) land requirements - cropping history sequence; 4) control of volunteers; 5) longevity of plants initially established; 6) genetic variability in the variety itself; and 7) minimizing mechanical contamination from harvesting through processing. Several requests came to the committee to consider recommendations limiting age of stands. The committee carefully considered the AOSCA standards as now established and found they are very clear in reference to the responsibility of originators or their designee indicating the age of stand in all classes of Certified seed. Some of the other seven factors such as land requirements and control of volunteer seedling are also a part of AOSCA regulations currently in force. Genetic variability should be a matter of concern for the originator and should be expressed by making limitations, just as for age of stand, in the application for certification. The committee invites alfalfa scientists to consider conducting research in all of the areas of concern in order to obtain precise information that can be used to establish regulations based on research data.

### Isolation

The committee discussed at length the merits of controlling genetic variability in the Foundation and Registered seed classes, recognizing that genetic integrity can be most easily controlled at these levels. Isolation distances for Foundation, Registered and Certified classes for fields both over and less than 5 acres were examined by the committee in detail. Lack of research was cited regarding the appropriateness of the present minimum standards of isolation for Foundation and Registered classes.

The committee reviewed both completed and ongoing research relating to isolation distances in the Certified seed class. Members of the committee have been accumulating data on genetic contamination related to isolation distances under different cultural and environmental conditions, such as field size, type of pollinators used, and climatic areas. Characteristics such as hardiness, disease resistance, and insect resistance have been used as indicators of contamination. This research involved fields from 10 acres to 25 acres in Idaho utilizing leafcutter bees and fields from 75 to 640 acres in California utilizing honeybees. The Idaho research by D. E. Brown et al. is summarized on page 24 of these proceedings. The California research is not as far along but indicates a minimum amount of contamination not exceeding 4 percent on the edge of the field and diminishing rapidly at increasing distances away from the source of contamination.

In view of the positive data accumulated to date, the committee unanimously approved the recommendation presented in the report to the OECD that was prepared by a special committee representing the Canadian Seed Growers Association and the Association of Official Seed Certifying Agencies in the United States. This report was endorsed by the Canada Department of Agriculture and the USDA and was presented to the OECD in May of 1978. This report is attached as Appendix 1, by request of the membership of the Alfalfa Improvement Conference.

The committee recommends that: 1) Originators of new varieties review the AOSCA regulations and set their own age of stand limits, agreeable with varietal characteristics, not only for Certified seed, but for Foundation and Registered classes. 2) The Foundation and Registered isolation distances should not be reduced further, pending research to examine the appropriateness of existing minimum standards for Foundation and Registered seed classes. 3) The NAIC endorse and accept the AOSCA and Canada Seed Growers Association Special Committee Report, chaired by A. A. Hanson of the USDA. This endorsement is based on previously published works, including theoretical considerations, the research reported by Brown et al. at the 26th Alfalfa Improvement Conference, June 1978, and a verbal presentation by Vern Marble on research conducted in California in 1976 and 1977. Added data will be obtained from fields of the 1978 seed crop from planned research underway in California and Idaho. 4) The incoming committee for the 27th Alfalfa Improvement Conference consider, through appropriate research, the appropriateness of present Foundation and Registered isolation distances.

D. E. Brown
D. W. Graffis
E. L. Granstaff
M. R. Hanna
W. R. Kehr
G. D. Moore
J. B. Moutray
V. L. Marble (Chairman)

## Isolation Distances for Varieties of Alfalfa*

Maintenance of an improved variety of a cross-pollinated species depends on the availability of an authentic source of pre-basic seed, together with adequate protection of the variety during initial stages of seed multiplication. If this is not achieved, then nothing is accomplished by imposing rigid regulations on the production of certified seed for commercial purposes (Griffith and Jones, 1952).

Systems are needed for all cross-pollinated herbage species that will insure the genetic integrity of the seed. In order to accomplish this objective, rules have been developed for producing certified seed of herbage crops. Although these rules were established originally on an empirical basis, they have demonstrated their overall effectiveness in the maintenance of genetic integrity.

There is a need, however, to reexamine the empirical isolation standards developed for alfalfa, because of the rapid increase in the number of improved varieties that are grown within major seed-producing regions. The land required to meet existing isolation requirements reduces the quantity of seed available to consumers under the certified label and represents a significant economic loss to producers. The question of isolation requirements for alfalfa seed requires consideration because field size and field shape can have a greater impact than isolation distance in keeping contamination at levels that do not affect field performance of certified seed used in the production of fodder.

Research data on isolation distances have been reported for vegetables (Bateman, 1947 and Crane and Mather, 1943), cotton (Green and Jones, 1953), forages (Griffiths, 1952 and 1956), and grasses (Jones and Newell, 1946) and Knowles, 1966). Most reported studies on the isolation requirements of alfalfa are based on fields of 2 ha or less. Hence, the results are directly applicable to the rules that should be followed in the maintenance of pre-basic, basic, and certified seed that will not be used for fodder purposes.

In studying barriers to outcrossing in alfalfa seed production, Jones et al (1971) found that contamination from other sources of alfalfa pollen

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*Statement prepared for presentation to the OECD by joint United States and Canadian committee representing AOSCA and Canadian Seed Growers Association. Committee members included: Lloyd Arnold, Arnold-Thomas Seed Service; Don Brewer, Oregon State University; Bob Eschbach, Washington State Department of Agriculture; Bernie Gopland, Canada Department of Agriculture; Wilf Bradnock, Canada Department of Agriculture; Vern Marble, University of California Crop Improvement Association; Ed McLaughlin, Canadian Seed Growers Association; and A. A. Hanson, USDA (Chairman).

was only slightly greater in border plots than in those plots located in the center of a 1.214 ha field of Ranger alfalfa. The authors concluded that field size had an important bearing on outcrossing. This conclusion was based on the observation that 9.14 x 9.14 m blocks of white flowered alfalfa had three times as much contamination as a 1.214 ha field of white flowered alfalfa (23.3% vs 7.1%). Pedersen et al. (1969) studied the theoretical effect of isolation distance on genetic contamination of alfalfa seed by planting 0.3 ha plots of white flowered alfalfa. Recognizing that white flowered alfalfa selections are not good seed producers, his calculations indicate only 10.5% contamination in a 4 ha field grown without isolation or a border.

Pankiw and Cooke (1976) planted a 4 ha field of a recessive white flowered alfalfa having a contiguous border (137 m) with a 4 ha field of the variety Beaver. Based on 2,000 seedlings analyzed from each isolation distance, the average contamination for the three years of the test was: 0-1 m, 17.5%; 1-10 m, 5%; 11-20 m, 2.5%; 21-30 m, 1.7%; 31-60 m, 2.5%; and 61-200 m, 1.1%. Thus, a 10 m border on a contiguous field would result in a contamination level below 2%. These findings indicate much lower levels of contamination in white flowered alfalfa selections than those calculated by Pedersen et al. (1969).

Under current seed certification rules, the 50 m isolation strip required for fields larger than 2 ha (certified seed from which will be used for fodder purposes only) can be either planted to another crop or left as bare ground. Also, the strip can be seeded with the same alfalfa variety and seed class and may be harvested either as uncertified seed or cut for hay. There is a good argument that blooming alfalfa of the same variety and seed class is a superior isolation barrier than an alfalfa-free isolation area.

If the size of an alfalfa field is such that the isolation zone ["Isolation zone" represents the area calculated by multiplying the length of the common border(s) with other varieties of alfalfa by the average width of the certified field falling within the 50 m isolation distance requirement.] is less than 10% of the entire field, then there are compelling arguments for eliminating the isolation requirement altogether. This proposal is based, in part, on the pollinating habits of the honey bee and leaf cutter bee that tend to visit blooms in a relatively restricted area on a single pollen collecting trip. Furthermore, since bees clean themselves quite thoroughly back at the hive or nest, little pollen remains to contaminate a new area foraged when the bees do not return to the same area of a field on the subsequent trip (Johansen, 1970).

A change is recommended in the isolation requirement for certified alfalfa seed produced for use in fodder production <u>only</u>. The specific proposal calls for eliminating the isolation requirement for alfalfa where the "isolation zone" is less than 10% of the entire field to be certified, provided there is clear (3m) line of demarcation between adjacent varieties.

The proposed change is shown in Appendix II of the OECD Scheme for the varietal certification of Herbage and Oil Seed. It is estimated that this change will keep the anticipated contamination level below 3 percent.

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## Committee on Preservation of Germplasm

The 1976 committee made two recommendations for the next germplasm committee. The present committee met on two different occasions along with a series of correspondence for the past 2 years. During this period, two papers related to alfalfa germplasm and its classification have been printed. These papers are 1) by Barnes, et al entitled Alfalfa Germplasm in the United States: its genetic vulnerability, use, improvement, and maintenance. (USDA Tech Bul 1571), and 2) by Gunn, Skrdla, and Spencer, entitled Classification of Medicago Sativa L. Using Legume Characters and Flower Colors (USDA Tech Bul 1574). The latter publication lists the various Medicago accessions, along with the new name of Medicago subspecies, flower color, type of pod coiling, growth habit, source, and so forth.

Following our germplasm committee meeting in June 1977 at Ames, Iowa, along with the CIAC meeting, our committee concurred with recommending three items to the National Committee as follows. There is a need for

1) germplasm exploration and collection
   a. foreign
   b. domestic
2) maintaining the present germplasms already collected and especially maintaining their purity.
3) a rhizobia collection (possibly tied with item 1 above).

The foreign exploration(s) should be in areas of the world that have not been covered in previous explorations or that may have been covered superficially. Those areas suggested include Yugoslavia, Greece, Turkey, Iran, Spain, Bolivia, Peru, Central Europe, and Russia. It is thought that a rhizobia collection could be done at the same time. We have the procedures for submitting plant germplasm exploration proposals. Since September 1977, an alfalfa exploration proposal was approved by the W-6 Technical Committee and referred to the ARS Plant Germination Coordinating Committee. An exploration is tentatively scheduled for FY 1980 to Yugoslavia and Greece-Phase I. Phase II into Turkey and Iran has not been fully proposed as of now.

We also recommend a domestic alfalfa exploration, especially in areas of the United States where escapes from cultivation have persisted for many years without the help of man. Areas for exploration may be in the midwest and western states as it relates to escapes from N. E. Hanson's collections of yellow-flowered alfalfas.

In summary of plant explorations, we recommend that the NAIC support our above recommendations of 1) Developing proposals for both foreign and domestic alfalfa explorations, and 2) making a rhizobia collection at the same time or separately. These proposals should be directed to SEA Plant Germplasm Coordinating Committee via the NC-7 Forage Crops Subcommittee and Technical Committee.

We also request the support of NAIC in developing a proposal to maintain the various germplasm already collected and especially maintaining their

purity via isolation cages. Dr. Hunt has a proposal to increase alfalfa introductions and other alfalfa lines under cages.

This subcommittee of the NAIC should be continued and instructed to develope appropriate proposals on behalf of the NAIC.

Submitted by:

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| B. P. Goplan | W. H. Skrdla |
| R. R. Kalton | A. C. Wilton |
| R. P. Murphy | D. A. Miller, Chairman |

Additional Information

Just prior to the 26th NAIC it was announced that alfalfa would be included as one of eight crop species to be included in a Germplasm Resources Information Project (GRIP) sponsored by the USDA. Dr. J. E. April was asked to present a brief overview of the project to the NAIC (see following report). The NAIC recommended that: "Members of the Alfalfa Technical Advisory Committee being formed by the coordinator of the NC-7 Regional Plant Introduction Station (curator for perennial alfalfa) also will serve on behalf of the NAIC to implement the proposals of this report. This committee will also serve to advise and direct the Germplasm Resources Information Project (GRIP), on behalf of the NAIC with respect to Alfalfa Germplasm, in its efforts to create an information system for the U.S. National Plant Germplasm System."

Following the 26th NAIC the USDA announced plans to implement a seed increase program for alfalfa plant introductions. Original seed of approximately 150 new plant introductions will be increased each year at Reno, Nev., beginning in 1979. It is intended that the increased seed will be available for evaluation and distribution. It will no longer be necessary to increase alfalfa plant introductions by open pollination.

## Germplasm Resources Information Project (GRIP)

J. E. April
Laboratory for Information Science in Agriculture
Colorado State University, Fort Collins, CO 80523

An information system is being developed for the National Plant Germplasm System (NPGS). The project responsible for this work is known as the Germplasm Resources Information Project (GRIP). Its primary objective is to increase access to germplasm through improved techniques of data management. The entire information system is expected to be implemented within 5 years.

The project is operated by a team of people, composed of staff members from the Information Sciences/Genetic Resources Program (IS/GR) of the University of Colorado, The Communication Data Services Division of USDA/SEA (CSDS), and participants within the NPGS. Initial funding for the project comes from the U.S. Department of Agriculture, Science and Education Administration.

In 1979, the GRIP team is emphasizing the development of three major functions of the overall system:

Information Exchange (IX)

Data and procedures associated with plant characteristics and the collection, storage, retrieval and distribution of this data

Registry (R)

Data and procedures associated with plant introduction and the tracking of germplasm throughout the NPGS.

Maintenance and Control (M/C)

Data and procedures associated with maintaining and distributing plant germplasm.

Prototypes for each of these functions are being installed at designated USDA centers (See Table 1). Following installations, the prototypes will be monitored in order to evaluate their effectiveness and to recommend modifications.

Various crop-specific advisory committees have been set up to determine what data should be included in the system from a user's perspective. The committees are composed of curators, researchers, and germplasm users from federal and state government, universities, and private industry. The committees provide advice for producing crop-specific descriptor lists, and their definitions and help in locating additional crop germplasm and backlog data. Finally, the committees provide evaluation strategies for each crop to ensure that the data are uniformly obtained and entered into the system.

order to ensure that the data are uniformly obtained and entered into the system.

Ultimately, the information system being developed to service the NPGS will allow data to be collected, stored, and updated at designated sites throughout the NPGS and will permit multiple-location access for data input and queries. Users will be able to interact through a natural language, permitting them to locate germplasm anywhere in the country.

Table 1.--Locations, crop(s), and information system at designated USDA centers

| Location | Crops | Functions |
|---|---|---|
| Beltsville, Md. | | |
| Small Grains Collection | Wheat | M/C, IX |
| PI Office | Au | R |
| Fort Collins, Colo., NSSL | Au | M/C, R |
| Pullman, Wash., W-6 | Phaseolus | M/C |
| Experiment, Ga., S-9 | Sorghum | IX |
| Sturgeon Bay, Wis., IR-1 | Potatoes | IX |
| Ames, Iowa, NC-7 | Tomatoes, Alfalfa | IX |
| Geneva, N.Y., NE-g | Peas | IX |

## Resolutions Committee Report

Be it resolved that the participants at the 1978 National Alfalfa Improvement Conference wish to express their appreciation to South Dakota State University, the Department of Plant Sciences, and the Department of Entomology-Zoology for hosting the conference. In particular, we also wish to thank Lyle Derscheid for making local arrangements and Mel Rumbaugh for his leadership as Conference Chairman.

Additionally, we also wish to thank the commercial organizations for sponsoring the luncheon in the Volstorff Ballroom.

Submitted by: R. L. Clark - Chairman
J. L. Kugler
R. J. Buker

## Nominations Committee Report

The nominations Committee presented the name of Edgar L. Sorensen, Research Agronomist, Agricultural Research, SEA, USDA, Manhattan, Kansas to the Conference. Dr. Sorensen was unanimously elected as Chairman for the 27th NAIC. The nominations committee consisted of H. Gasser, J. L. Mings, and M. B. Tesar, Chairman.

Dr. Donald E. Brown, Senior Agronomist, Land O'Lakes, Caldwell, Idaho, was elected by industry to serve as it's representative on the Executive Committee of the 27th NAIC.

On January 28, 1978, the Executive Committee of the 26th NAIC recommended to the Association of Official Seed Certifying Agencies (AOSCA) that B. A. Melton, New Mexico State University, Las Cruces, would serve as principal delegate from the NAIC on the National Certified Alfalfa Variety Review Board beginning July 1, 1978. Dr. E. L. Sorensen was recommended to serve as alternate delegate until July 1, 1980 when he will become delegate.

## Plans for the 1980 National Alfalfa Improvement Conference

An invitation was received to hold the 1980 conference on the University of Wisconsin campus at Madison, Wisconsin. The invitation was accepted. The date will be July 8, 9, and 10.

The locations committee consisted of R. S. Fulkerson, R. E. Ensign, R. G. Helgesen, and E. T. Bingham, Chairman.

## History of National Alfalfa Improvement Conference

| No. | Year | | | |
|---|---|---|---|---|
| 1 | 1934 | Lincoln, NE | T. A. Kiesselbach | H. M. Tysdal |
| 2 | 1934 | Washington, DC | A. J. Pieters | H. M. Tysdal |
| 3 | 1935 | St. Paul, MN | H. L. Westover | H. L. Westover |
| 4 | 1936 | Madison, WI | R. A. Brink | H. M. Tysdal |
| 5 | 1937 | Chicago, IL | R. A. Brink | H. L. Westover |
| 6 | 1938 | Manhattan, KS | H. M. Tysdal | H. L. Westover |
| 7 | 1939 | New Orleans, LA | H. M. Tysdal | H. L. Westover |
| 8 | 1940 | Fort Collins, CO | L. F. Graber | H. L. Westover |
| 9 | 1942 | St. Louis, MO | L. F. Graber | H. L. Westover |
| 10 | 1946 | Logan, UT | J. W. Carlson | H. M. Tysdal |
| 11 | 1948 | Lincoln, NE | C. O. Grandfield | H. M. Tysdal |
| 12 | 1950 | Lethbridge, Canada | T. M. Stevenson | O. S. Aamodt |
| 13 | 1952 | Raleigh, NC | R. P. Murphy | O. S. Aamodt |
| 14 | 1954 | Davis, CA | O. F. Smith | H. O. Graumann |
| 15 | 1956 | St. Paul, MN | C. P. Wilsie | H. O. Graumann |
| 16 | 1958 | Ithaca, NY | C. H. Hanson | H. O. Graumann |
| 17 | 1960 | Saskatoon, Canada | J. L. Bolton | C. H. Hanson |
| 18 | 1962 | Davis, CA | E. H. Stanford | C. H. Hanson |
| 19 | 1964 | Lafayette, IN | R. L. Davis | C. H. Hanson |
| 20 | 1966 | Univ. Park, PA | H. L. Carnahan | C. H. Hanson |
| 21 | 1968 | Reno, NV | W. R. Kehr | C. H. Hanson |
| 22 | 1970 | Urbana, IL | R. R. Hill, Jr. | C. H. Hanson |
| 23 | 1972 | Ottawa, Canada | D. H. Heirichs | C. H. Hanson |
| 24 | 1974 | Tucson, AZ | Dale Smith | C. H. Hanson and D. K. Barnes |
| 25 | 1976 | Ithaca, NY | M. W. Pedersen | D. K. Barnes |
| 26 | 1978 | Brookings, SD | M. D. Rumbaugh | D. K. Barnes |
| 27 | 1980 | Madison, WI | E. L. Sorensen | D. K. Barnes |

## Secretary's Report

The National Alfalfa Improvement Conference (NAIC) is listed as a nonprofit organization by the U.S. Government. A 5-3/4 percent savings account is maintained at the Twin City Federal Savings and Loan, Roseville, Minn. 55113. All income in the account has been from either surpluses of registration monies from NAIC national conferences or from interest earned in the account. Transactions during the last 2 years include:

| | | |
|---|---|---|
| Balance on hand (8-16-76) | | 378.28 |
| Income | | |
| Interest 8-16-76 to 3-31-78 | 57.88 | |
| Registration surplus 25th NAIC | 300.00 | |
| | | 357.88 |
| Disbursements (Printing costs) | | |
| Address and activity directory - 500 copies (10-14-77) | 173.83 | |
| Notice 26th NAIC and 1976 National Certified Alfalfa Review Board Report (10-20-77) | 43.78 | |
| Information for 26th NAIC Registration and 1977 National Certified Alfalfa Review Board Report (3-15-78) | 131.81 | |
| Program for 26th NAIC - 200 copies (6-1-78) | 53.14 | |
| | | (402.56) |
| Balance on hand (6-5-78) | | 333.60 |

During the last 2 years I have continued my effort to update the NAIC mailing list. In October 1977, the first "Alfalfa Scientist--address and activity directory" was completed and distributed. Response to this activity was positive, indicating that the idea of a directory should be maintained and updated. It is my goal to prepare a new directory approximately every 2 years. During the last 2 years, the NAIC mailing list has increased by nearly 50 percent.

| Source | Scientist receiving NAIC Information | |
|---|---|---|
| | 25th NAIC | 26th NAIC |
| United States | 168 | 225 |
| Canada and Mexico | 28 | 51 |
| Non-North American | 30 | 53 |
| Total | 226 | 329 |

The unanticipated interest in alfalfa information during the last 2 years exhausted the 360 copies printed of the 25th NAIC Report and the 2,700 copies printed of the publication on "Standard Tests to Characterize Pest Resistance". Increased numbers of copies of this 26th NAIC Report and of the revised 'Standard Tests' publication will be ordered. Copies of the two publications - "Improved Breeding Lines of Alfalfa," ARM-W-5, 59 p. (1978) and "Alfalfa Germplasm in the United States: Genetic vulnerability, use, improvement, and maintenance", USDA Tech. Bull. 1571, 21 p. (1977) are still available and can be requested from me. Both publications include information developed by committees of the NAIC and then published by the U. S. Department of Agriculture.

I have enjoyed working with Mel Rumbaugh and the other members of the 26th Alfalfa Improvement Conference during the last 2 years. I would like to give special recognition to all of the staff and students at South Dakota State University who spent a great deal of time and effort as local hosts to make the 26th NAIC a success.

I am looking forward to working with members of the 27th NAIC. If there are suggestions as to how the activities of the NAIC can be improved, please contact either me or the chairman, Dr. E. L. Sorensen.

Respectfully submitted:

D. K. Barnes
Permanent Secretary NAIC

## Alfalfa Scientists on Alfalfa Improvement Conference Mailing List

United States

R. M. Ahring
J. T. Andaloro
R. E. Anderson
J. Arledge
K. L. Athow
J. D. Axtell
M. R. Azizi
S. J. Baluch
R. A. Barford
R. E. Barker
D. K. Barnes
G. L. Barnes
R. F. Barnes
J. Barzen
L. N. Bass
J. E. Baylor
D. F. Beard
R. Berberet
R. R. Billings
E. T. Bingham
R. Bitner
K. E. Bohnenblust
J. H. Bouton
M. A. Brick
D. E. Brown
R. J. Buker
G. W. Burton
T. H. Busbice
G. R. Buss
R. A. Byers
J. L. Caddel
W. M. Campbell
G. E. Carlson
I. T. Carlson
N. J. Chatterton
D. O. Chilcote
R. L. Clark
R. W. Cleveland
Miller Seed Co.
B. V. Conger
C. S. Cooper
L. J. Crain
L. Cranfill
R. E. Croft
D. G. Cummins
R. Delaney
L. A. Derscheid
R. L. Ditterline
D. L. Dodds
W. M. Dowler
P. Duhigg
G. M. Dunn
C. R. Edwards
J. H. Elgin, Jr.
A. H. Ellingboe
F. C. Elliott
R. D. Ensign
L. Epstein
D. C. Erwin
D. W. Evans
K. H. Evans
S. Ferguson
G. W. Fick
J. L. Force
H. R. Fortmann
R. V. Frakes
A. A. Franklin, Jr.
H. A. Fribourg
F. I. Frosheiser
R. H. Garrison
J. R. Gerwing
P. B. Gibson
R. O. Gifford
D. W. Graffis
J. H. Graham
E. L. Granstaff
J. Gregory
H. R. Guenthner
D. L. Gustine
R. Haaland
D. L. Haeseker
C. H. Hanson
L. P. Hart
R. H. Hart
B. J. Hartman
W. G. Hartman
T. L. Harvey
J. Hawkins
G. H. Heichel
R. Heisey
R. G. Helgeson
Z. R. Helsel
G. Hewitt
E. Hijano
R. R. Hill, Jr.
L. Hofmann
B. Hohrein
E. C. Holt
E. Horber
E. S. Horner
R. D. Horrocks
W. F. Hovde
B. Howard
A. A. Hower, Jr.
O. J. Hunt
S. M. Hurst
J. A. Jackobs
E. H. Jensen
A. L. Johnson
K. J. Johnson
E. R. Jones
R. R. Kalton
I. I. Kawaguchi
W. R. Kehr
H. Kinder
W. K. Knipe
T. R. Knous
J. J. Kolar
J. Kugler
H. M. Laude
A. G. Law
K. T. Leath
B. M. Leese
W. F. Lehman
R. C. Leslie
H. D. Loden
G. M. Loper
C. C. Lowe
R. F. Lucey
W. R. Luellen
H. R. MacWilliam
P. Magidman
G. R. Manglitze
V. L. Marble
D. B. Marcum
G. C. Marten
N. P. Martin
H. P. Massoth
A. G. Matches
N. P. Maxon
D. P. Maxwell
M. McCaslin
W. E. McMurphy
J. E. McMurtrey
R. D. Meeks
B. A. Melton
D. W. Meyer
R. L. Millar
D. A. Miller
J. W. Miller
M. K. Miller
J. L. Mings
J. A. Mollet
C. L. Mondart, Jr.
G. D. Moore
L. E. Moser
J. Moutray
J. P. Mueller
R. D. Munson
B. Murphy
R. P. Murphy
M. W. Nielson
M. S. Offutt
R. L. Ogden
S. A. Ostazeski
G. A. Page
W. D. Pardee
F. D. Parker
B. C. Pass
R. D. Pausch
R. N. Peaden
D. Peck
M. W. Pedersen
G. A. Pedersen
T. M. Peters
M. A. Peterson
J. Plaskowitz
R. H. Ratcliffe
J. H. Reynolds
R. Richardson
C. M. Rincker
M. L. Risius
S. J. Roberts
G. Robison
D. A. Rohweder
L. M. Rommann
R. R. Ronnenkamp
H. Rothbart
E. H. Row
O. C. Ruelke
M. D. Rumbaugh
C. Rumberg
W. B. Rusconi
R. G. Sackett

United States (Continued)

R. J. Schaeffer
M. H. Schonhorst
T. Schultz
J. M. Scriber
R. Seaney
R. E. Shade
A. F. Shaw
C. C. Sheaffer
R. T. Sherwood
J. R. Sholar
K. Skarien
W. H. Skrdla
D. H. Smith
Dale Smith
D. L. Smith
D. M. Smith
G. R. Smith
K. D. Smith
Odel Smith
D. Sorensen
E. L. Sorensen
T. Stadniuk
T. G. Strachota
D. L. Stuteville
J. E. Sumberg
R. E. Swindell
C. M. Taliaferro
N. L. Taylor
R. L. Taylor
W. C. Templeton
M. B. Tesar
L. R. Teuber
R. L. Teweles
J. H. Thomas
M. Thompson
B. D. Thyr
C. Tiernan
R. D. Timmons
C. E. Townsend
P. P. Troutman
J. W. Vaccaro
N. VanAlfen
C. P. Vance
R. W. VanKeuren
A. Vaziri
B. C. Venuto
D. R. Viands
D. M. Vietor
F. R. Vigil
L. R. Vough
C. Walters
M. F. Walton
J. B. Washko
W. A. Way
W. F. Wedin
E. D. Weimortz
R. E. Welty
F. E. Westbrook
L. Wiesner
S. C. Wiggans
G. B. Wiklund
H. T. Wilkinson
M. C. Wilson
M. Wilson
T. E. Wilson
A. C. Wilton
G. M. Wood
K. Wood
S. T. Yen
J. A. Yungen

Canada

H. Baenziger
J. Belicek
J. S. Bubar
B. R. Christie
K. W. Clark
J. Cooper
J. G. N. Davidson
L. Dessureaux
C. R. Ellis
T. Faechner
N. Faust
R. S. Fulkerson
H. Gasser
B. P. Goplen
G. Gorsky
H. Gross
M. R. Hanna
A. M. Harper
E. J. Hawn
D. H. Heinrichs
R. E. Howarth
L. A. Hunt
R. B. Irvine
H. T. Kunelius
T. Lawrence
W. C. Leask
G. L. Lees
K. Lesins
G. E. McCann
J. D. McElgunn
J. S. McKenzie
R. J. McLaughin
F. Mederick
R. Michaud
M. O'Guilbord
P. Pankiw
R. Paquin
M. C. Pick
K. W. Richards
R. S. Sadasivaiah
B. D. Schaber
A. Slinkard
J. A. Sullivan
M. Suzuki
G. Y. Tan
L. S. Thompson
D. T. Tomes
C. B. Willis
R. B. Wynn-Williams

Mexico

R. G. Calderon
J. A. Rascon

Non-North American

R. E. Avendano
C. B. Banchero
J. Mck. Blackstock
J. Bocsa
Z. Bojtos
O. L. Borges
D. Bosnjak
R. Bournoville
R. A. Bray
J. Buglos
F. Charpentier
O. De Cordova
A. G. Davis
G. C. deKock
B. Dennis
A. Dobias
J. A. Douglas
G. G. Drummond
M. W. Dunbier
H. S. Easton
M. G. Echevarria
M. Falcinelli
F. Fujimoto
R. Garboucheva
P. Gayraud
P. Guy
J. Irwin
C. D. Itria
A. Jelinovska
H. A. Jonsson
I. D. Kaehne
H. Kontsiotan
A. Kornher
J. Kristek
M. E. Lattimore
J. R. Leclercq
R. Lykora
Y. Maki
Manajen
K. Manninger
C. Moschetti
B. Nagy
A. Panella
Picard
M. P. Plan
M. S. Radwan
J. Rod
H. H. Rogers
V. E. Rogers
P. Rotili
F. W. Schnell
B. S. Sidhu
U. Simon
O. R. Southwood
Z. Staszewski
R. Steuckardt
K. Suginobu
S. Suzuki
G. A. Tome
A. Vachunova
P. Varga
D. Waterhouse

National Alfalfa Improvement Conference (NAIC)
Mailing List Questionnaire

Returning this questionnaire indicates that you would either like to be added to the NAIC mailing list or that you have an address or activity change.

1. Name: ______________________________ 2. Date: ________________

3. Mailing Address: ____________________ 4. Office Telephone No. _______

____________________

____________________

5. Present activities with alfalfa: Check appropriate blank(s).

Research Activities

A ___ Breeding
B ___ Entomology
C ___ Nematology
D ___ Pathology
E ___ Physiology
F ___ Forage Production
G ___ Seed Production
H ___ Utilization
I ___ Chemical and Quality Analysis

Non-Research Activities

J ___ Administration
K ___ Extension
L ___ Forage Producer
M ___ Marketing
N ___ Seed Producer
O ___ Student
P ___ Teacher
Q ___ Certification and Variety Protection
R ___ Writer or Publisher
S ___ Other ________________

6. Would you like new variety and germplasm release information? Yes __ No __

For Canadian and USA Scientists Only:

7. Which Regional Alfalfa Improvement Conference(s) would you like to receive information about? _____ Eastern, _____ Central, _____ Western

8. What best describes your employment situation: ___ USDA, ___ SAES, ___ U. S. Private Industry, ___ Canadian Public, ___ Canadian Private

Note: Please call this questionnaire to the attention of your colleagues and employees who you think should be on the NAIC mailing list.

Return to: D. K. Barnes
Department of Agronomy & Plant Genetics
University of Minnesota
St. Paul, MN 55108



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UNITED STATES DEPARTMENT OF AGRICULTURE
SCIENCE AND EDUCATION ADMINISTRATION
AGRICULTURAL RESEARCH
NORTH CENTRAL REGION

DEPARTMENT OF AGRONOMY & PLANT GENETICS
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